Technical Report 795

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Computer-Mediated Group Processes in Distributed Command and Control Systems

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Research Institute for the Behavioral and Social Sciences

June 1988

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY 2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) ARI Technical Report 795
6a. NAME OF PERFORMING ORGANIZATION Vreuls Research Corporation 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION U.S. Army Research Institute Field Unit
6c. ADDRESS (City, State, and ZIP Code) 68 Long Court, Suite E Thousand Oaks, CA 91360	7b. ADDRESS (City, State, and ZIP Code) P.O. Box 3407 Fort Leavenworth, KS 66027-0347
8a. NAME OF FUNDING/SPONSORING ORGANIZATION U.S. Army Research Institute 8b. OFFICE SYMBOL (If applicable) PERI-SZ	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER MDA903-86-C-0210
8c. ADDRESS (City, State, and ZIP Code) 5001 Eisenhower Avenue Alexandria, VA 22333-5600	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 62717A PROJECT NO. 2Q162717A790 TASK NO. 144 WORK UNIT ACCESSION NO. C2

11. TITLE (Include Security Classification)

Computer-Mediated Group Processes in Distributed Command and Control Systems

12. PERSONAL AUTHOR(S) Suzanne P. Weisband, James M. Linville, Michael J. Liebhaber, Richard W. Obermayer (Vreuls Research), and Jon J. Fallesen (ARI)

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 03/87 TO 03/88	1988, June	61

16. SUPPLEMENTARY NOTATION

The Contracting Officer's Representative was Dr. Jon Fallesen of ARI.

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Command and control; Group dynamics; Computer-mediated work; Decision making. (KP); Research issues; Staff operations (Continued)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Carefully designed procedures for command and control (C^2) staff operations are critical to realize effective direction and management of tactical forces. The survivability of command posts and the functions they serve are critical as well. With the increased use of battlefield automated systems, it will be easier to distribute Army C^2 staffs and their functions in favor of increased survivability. In anticipation of greater computer-mediated communications and task procedures, this report considers group and human factors issues requiring study. Previous behavioral research findings on team and group processes, distributed communications, and computer-mediation are discussed. Characteristics of operations in a distributed, computer-mediated mode are projected for C^2 staffs. Issues that may induce decrements or increments in performance are identified and recommended as experimental variables in human performance research. Keywords:

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION	
22a. NAME OF RESPONSIBLE INDIVIDUAL Jon J. Fallesen	22b. TELEPHONE (Include Area Code) (913) 684-4933	22c. OFFICE SYMBOL PERI-SL

DD Form 1473, JUN 86 Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

ARI Technical Report 795

18. Subject Terms (Continued)

Computer-supported cooperative work
Communication
Command post operations
Team performance

Technical Report 795

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Office, Deputy Chief of Staff for Personnel

Department of the Army

June 1988

Army Project Number
2Q162717A790

Human Performance Effectiveness

Approved for public release; distribution unlimited.

FOREWORD

The incorporation of automation in command and control (C^2) headquarters staffs has presented the behavioral research community with an intriguing problem. Typically, higher echelon command posts display very high signatures as targets. The introduction of computers allows for the reduction of signatures through separation and dispersion of various elements of a command post. Along with the physical change associated with further dispersion will come a dramatic change in the procedures of command staff operations. Computers will allow tasks to be completed by staff members who are not operating in a face-to-face mode but in a computer-mediated mode. The challenge for research and development will be to determine and compensate for performance difficulties and to identify opportunities where computer-mediation can bring about improved performance.

This report, supported by the Fort Leavenworth Field Unit, identifies research issues for command and control staffs who will operate in a computer-mediated environment. The Army Research Institute has initiated research to examine selected issues identified in this report. Variables of communication media and remote supervision are being studied to identify differences in performance on a typical staff planning task, and additional studies also are planned to address this challenging research topic.

Edgar M Johnson

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COMPUTER-MEDIATED GROUP PROCESSES IN DISTRIBUTED COMMAND AND CONTROL SYSTEMS

EXECUTIVE SUMMARY

Requirement:

The increased use of computers in command and control tasks and functions may create staff performance problems that will need to be resolved before effective use is realized. On the positive side, research may identify opportunities for improved performance that had not been possible in previous systems. Careful delineation of performance issues of computer-mediated group processes is needed.

Procedure:

The identification and selection of key research issues followed a three-step procedure. Previous research was assessed from the behavioral literature on team characteristics, group processes, group decision making, distributed group communications, communication networks, and computer-mediated communication effects. The nature of the previous research paradigms and methods was considered.

Current command and control staffs were described in terms of their mission, structure, decision-making processes, and interaction as they relate to distributed functions. Projections were made as to the change in these factors under increased dispersion and computer-mediation.

The implications of previous research were considered for their impact on the projected concepts of computer-mediated command staff performance. New and recurrent issues were specified and judged for those most worthy of early investigation.

Findings:

Issues recommended for initial study of computer-mediated performance in distributed command and control systems include (a) graphic communication technology, (b) inclusion of voice communication with computer-mediation, (c) leading or supervising group processes in a computer-mediated mode, (d) functional groupings of staff elements and the effect of loss of one of the subgroups, and (e) the effect of a change from face-to-face to computer-mediated processes on norms of staff procedures and products.

Utilization of Findings:

This report identifies key behavioral issues and concerns anticipated in the transition from face-to-face staff procedures in a collocated mode to computer-mediated processes in a distributed mode. Research to address the recommended issues will produce empirically based judgments for modifications to staff procedures, organizations, and system design.

COMPUTER-MEDIATED GROUP PROCESSES IN DISTRIBUTED COMMAND AND CONTROL SYSTEMS

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COMPUTER-MEDIATED GROUP PROCESSES IN DISTRIBUTED
COMMAND AND CONTROL SYSTEMS

SECTION I

PROBLEM AND BACKGROUND

Although the responsibility for military staff task accomplishment is assigned functionally, the majority of tasks are accomplished by several people providing inputs and products to the functional supervisor. These input and product providers may or may not belong to the same functional supervisor, may be separated from one another and may be separated from the functional supervisor. The functional supervisor has the overall responsibility for task accomplishment, yet is dependent upon other staff personnel and sections to provide information, data, and products. The other personnel will have to perform various sub-tasks that lead to major task accomplishment. Coordination, conflict resolution, guidance and data sharing are required. This can be done routinely by staff members that have the opportunity to perform in a face-to-face environment. Once the staff members or sections are separated from one another, this once-routine coordination becomes more difficult. Coordination may have to be done by voice communications only. This remoteness is anticipated to have an adverse effect on task accomplishment.

This report documents a review of the potential for communicating through computers (computer-mediated communications) as a means for augmenting distributed (i.e., geographically separated) command and control processes. The characteristics of the problem are amplified in the remainder of this chapter. The research literature is reviewed in Section II, and the military and staff considerations are discussed in Section III. The report concludes with a contrast of the research and staff reviews, and a discussion of the major issues. Potential research is discussed and specific recommendations for experimentation are made.

Problem

The command and control (C2) system is currently dispersed. The system is dispersed throughout the battlefield and is connected through the available communication systems. Future C2 systems will require even more dispersal. This dispersal will be required for survivability and to increase the commander's sphere of influence and breadth of command and control. It may provide increased protection to the force as a whole, but it will not necessarily enhance the survivability of function, information and coordination.

To enhance the capability of remote staffs to share information, provide supervision, coordinate on staff tasks, perform analysis and provide recommendations, graphic communications may be required in the form of computer aiding, shared graphics, shared data bases and two way graphic communication. Voice communications alone will probably not support the collaboration and coordination required for successful task accomplishment. The technological capabilities of computer networks may improve the capability to share data, resolve conflicts, and provide guidance.

SECTION II

ANALYSIS OF PREVIOUS RESEARCH

A review of the literature was conducted as preparation for research planning as well as to identify prominent gaps in available knowledge. To guide this review, we explored the literature in an attempt to answer the following questions:

- Which previous studies could be appropriately applied to the military staff, and what specific group characteristics must be considered for the planned research?

- By what processes do groups achieve their goals? We wished to know which processes might be affected by placing team members in remote locations, and which processes might be augmented with computer technology.

- What specific knowledge is available in the literature that can be applied to computer-mediated communications among distributed command staffs?

- What information is available to guide the design of experiments concerning computer-mediation of distributed military staffs? For example, what factors influence team performance? What measurements of group performance and processes have been defined?

These questions will be addressed in the following sections, followed by conclusions with regard to the primary issues which have been identified.

Team Characteristics

The military staff is organized as a single, cohesive group for the purpose of assisting the commander accomplish the mission. Some of the ways military staffs go about assisting the commander include providing accurate and timely information, assessing and recommending courses of action which will best accomplish the mission, and preparing plans and orders based on those recommendations.

Many military groups can best be described as teams. In the literature on group research, a team is considered one kind of small group (Forsyth, 1983) with important characteristics that distinguish it from the small groups which are usually studied. For example, a team is typically well-organized, highly structured, and has formal operating procedures (e.g., Meister, 1976). In contrast, an ordinary small group may be informal, have an indefinite or loose structure, and have assumed rather than designated roles and procedures. A team consists of at least two people working towards a common goal; each member of a team is assigned a specific

role or function to perform, and each member is dependent upon the other group members in order to complete their goal (e.g., Dyer, 1984; Klaus & Glaser, 1968; Rizzo, 1980).

Nevertheless, there is the potential for informal small group behavior even in highly structured teams. For example, unanticipated situations can occur which require unprecedented or innovative action from the command staff. In such situations, the command staff may adopt an ad hoc structure and may utilize informal group processes.

Since teams are goal-, or mission-oriented, the specific context in which the team will operate must be considered before any training or evaluation technique can be applied (Wagner, Hibbits, Rosenblatt and Schulz, 1977). Collins (1977) frames his discussion of group-like phenomena in terms of the definition by Smith (1967):

- a team is a set of two or more individuals jointly characterized by
    - a network of relevant communications,
    - a shared sense of collective identity, and
    - one or more shared goals with associated norms.

There should be a sharp increase in group-like phenomena once these conditions are satisfied. Useful group phenomena include: awareness of accomplishment, feelings of satisfaction, stronger desire for success, working harder, coordinating more effectively, low interpersonal strain, attracted to membership, and more productivity (Zander, 1971). However, there are costs associated with team activity. Steiner (1966, 1972) indicates that there may be productivity losses associated with task communication and coordination requirements.

Military teams usually exhibit a high degree of formalization. A team is formalized to the extent that "the rules governing behavior are precisely and explicitly stated and to the extent that the roles and role relations are prescribed independently of the personal attributes of individuals occupying positions in the structure" (Scott, 1981, p. 20). Thus, members of military staffs and teams are assigned specific positions because they possess the requisite skills for completing the team goal or mission.

Military staff members conduct their activities and interactions with each other for the purpose of achieving specified goals or mission statements. Such statements are explicit, clearly defined, and provide unambiguous criteria for selecting among alternative activities. For example, they specify what tasks are to be performed, who will perform the tasks, and what the criteria are to complete the task. In military C2 staffs, task activities are divided into six broad functions: personnel, intelligence, operations and training, communications-electronics, logistics, and civil-military operations. The relative importance of these six functions depends on the mission, the level of command and the environment.

The criteria of formalization and goal specialization influences the nature of group interaction and the way tasks are performed. Staff responsibilities are carried out along functional lines, and those lines are standardized for all staff sections. Since no one member of a team has sufficient information to complete the task, information must be shared to allow the group as a whole to produce an answer. Information that is not completely shared by those with a role in shaping the decision is what is often referred to as "distributed decision making" (e.g., Fischhoff & Johnson, 1985). Distributed decision making involves coordination, and decision makers are influenced by the information (and interpretations) reported by others and by the pre-decisions of their predecessors and superiors. The command and control of military functions currently includes distributed decision making.

Group Processes

Group Decision Making and Problem Solving

Decision making involves the selection or choice of some feature or some action from a set of uncertain alternatives (Matlin, 1983; Wheatley, 1981); it is the ability to derive information from data and use it to assess alternative hypotheses and options (Wohl, 1981). Military leaders are decision makers; they generate and assess hypotheses and options from a set of alternatives. Problem solving, on the other hand, involves situations in which attaining a certain goal is desirable, the goal is not readily available and the alternatives are not clear (Matlin, 1983).

In each problem there is (1) the original state, (2) the goal state, and (3) the rules. Means-ends analysis is a strategy in which the problem solver divides the problem into a number of sub-problems. It involves figuring out the "ends" and then determining what "means" to use to reach those ends. Problem solving tasks have been examined with computer simulation programs (e.g., Newell and Simon, 1972). Military staffs who perform the sub-tasks necessary to complete the mission are problem solvers. They use a set of rules and procedures to lead them to a correct or acceptable solution.

Given that most people (including experts) are prone to judgmental errors and biases, making decisions (even in highly structured and formalized tasks) is difficult (e.g., Bazerman, 1986; Kahneman, Slovic and Tversky, 1982; Slovic, Fischhoff and Lichtenstein, 1977). In order to make the task of decision making less complex and difficult, people use a small number of heuristic, or "rules of thumb" strategies to guide their decisions (see Kahneman et al., 1982 for a review of these heuristics). According to Tversky and Kahneman (1974) there are three basic methods people use:

(1) Representativeness. Links of association between A and B are evaluated by considering the similarity of the essential features of A and B. For example, we often judge people on the basis of population stereotypes. Other examples of how people use representativeness in decision making include ignoring the sample size, regression toward the mean, ignoring base rate or proportions in the population, and overconfidence in their own general knowledge.

(2) Availability. An event is judged likely or frequent if it is easy to recall or imagine relevant instances. Factors such as recency, familiarity, and saliency or vividness can influence availability and lead to a distortion in frequency estimation.

(3) Anchoring and Adjustment. A first approximation to the judgment acts as an anchor. As more information comes in, adjustments are made on the basis of the anchor. Thus, people typically rely too heavily on the anchor, and their adjustments are too small. Thus, the anchor proves to be "remarkably resistant to further information, alternative modes of reasoning, and even logical or evidential challenges" (Nisbett and Ross, 1980, p. 41).

Reliance on these simple methods seems to come from two sources: One is people's limited mental computation capacity; they have to simplify things in order to get on with life. The second is their lack of training in decision making, leading them to come up with ways that make sense, but have not benefited from rigorous scrutiny (Fischhoff & Johnson, 1985).

Phases of Group Decision Making

Group decision making processes have been well studied (Bell, 1982; Chapanis, Ochsman, Parrish, & Weeks, 1972; Davis & Smith, 1983; Metlay, Liebling, Silverstein, Halatyn, Zimberg, & Richter, 1985; Nieva, Fleishman, & Rieck, 1978; Schweiger, Anderson, & Locke, 1985; Vallee, Johansen, Randolph, & Hastings, 1978). The basic phases that groups go through to accomplish their goals are:

(1) Identify the problem
(2) Gather relevant information
(3) Make individual and group assessments
(4) Discuss and resolve differences
(5) Propose a solution

A provisional taxonomy of team functions, developed by Nieva et al. (1978), and discussed in Fleishman & Quaintance (1984, p. 416), is shown in Table 1. Some preliminary study of this taxonomy has begun (Shiflett, 1979) and attempts have been made to develop a system for classifying group functions.

Table 1

Provisional Taxonomy of Team Performance

I.	Orientation functions
	A. Information exchange about team goals
	B. Information exchange about team tasks
	C. Information exchange about member resources and constraints
	D. Information exchange of situational resources and constraints
II.	Organizational functions
	A. Matching member resources to task requirements
	B. Response coordination and sequencing of activities
	C. Activity pacing
	D. Priority assignment among tasks
	E. Load balancing of tasks by members
III.	Adaptation functions
	A. Mutual critical evaluation and correction of error
	B. Mutual compensatory performance
	C. Mutual compensatory timing
IV.	Motivational functions
	A. Development of team norms
	B. Generating acceptance of team performance norms
	C. Establishing team-level performance-rewards linkages
	D. Reinforcement of task orientation
	E. Balancing team orientation with individual competition
	F. Resolution of performance-relevant conflicts

A study by Morgan, Glickman, Woodard, Blaiwes, and Salas (1986) examined dynamic processes that occurred over time during team training, to develop a generalized model of team evolution and maturation. They adopted a general framework from Gersick (1985) (first meeting, phase I, transition, phase II, completion) and Tuckman (1965) (pre-forming, forming, storming, norming, performing-I, reforming, performing-II, and conforming). Within this structure, they identified two parallel-developing dynamic processes as listed in Table 2.

Table 2

Model of Team Evolution and Maturation

I. Operational team skills training
   A. development of task assignments
   B. orientation to task
   C. emotional response to task demands
   D. open exchange of relevant interpretations
   E. emergence of solutions
   F. adjustment to framework
   G. drive to completion
   H. delivery and completion of task
   I. withdrawal from task
   J. review of accomplishments

II. Generic team skills training
   A. investigation of the group
   B. testing of dependence
   C. intragroup conflict
   D. development of group cohesion
   E. development of role relatedness
   F. refinement of roles
   G. fulfillment of roles
   H. adjustment to environmental demands
   I. exiting from group
   J. remembering group

Distributed-Group Communication

In addition to being instrumental in effective decision making, communication is key to the successful completion of a mission. In distributed decision making systems, communication networks are complex. A successful C2 system will support the battle in combination with the intelligent use of communication skills and technological tools that are available. A successful C2 system must be able to rapidly coordinate information with other local and remote C2 systems, provide estimates in a timely fashion, act immediately on the commander's guidance, and prepare and disseminate orders. The inability to accomplish these tasks will likely cause the maneuver units to enter the battlefield in a reactive rather than an active mode.

Currently, staff officers working within functional lines communicate face-to-face, sharing the same physical displays and the same data. Sometimes it is necessary to communicate with a staff counterpart at another geographical location. In these cases, communication is often by radio, wire or courier. The introduction of electronic communication, through computer, video and audio teleconferencing is likely to affect how tasks are accomplished, if, for example, data and displays are shared electronically.

Electronic communication is defined as exchanging spoken words, visual images, or typewritten messages by people who may be far apart (Johansen, Vallee, & Spangler, 1979). Examples include computer conferencing, video and audio teleconferencing, electronic mail systems, and graphic display systems with drawing aids.

In this section, we present a literature review of the effects of various communication media on group decision making. From these effects, we discuss some advantages and disadvantages for implementing electronic communication networks.

Types of Communication Networks

Three types of electronic communication networks -- video teleconferencing, audio teleconferencing, and computer conferencing -- are discussed as alternatives to face-to-face communication. Video teleconferencing is a group-to-group medium, typically with only two groups meeting at any time. While video systems try to mimic face-to-face meetings, many people still feel uncomfortable "on camera" (Johansen et al., 1979). Unlike computer and audio networks, video teleconferencing has not been used much. A major reason for the low usage figures can be traced to the difficulty in connecting more than two sites at any one time, while many groups have members at several sites. Others question whether video teleconferencing is anything more than expensive hoopla. A broadcast television-quality video image is very expensive. That is, video is a "wide band" communications medium: the bandwidth (size of the signal carrier) must be very large in order to send all this visual information continuously. In contrast, video systems using "freeze-frame" images use a narrower bandwidth because information can be sent more slowly. Thus, the costs associated with the bandwidth required for video are formidable. However, it is possible that technological developments, such as video compression techniques, optical fiber signal transmissions, and efficient use of satellites, will produce major cost reductions.

Audio teleconferencing may be quite adaptable to group decision making needs. The costs are low, using inexpensive telephone lines. Permanently installed conference rooms which use dedicated lines are more expensive to use, but they provide greater reliability and generally higher voice quality. One problem with audio teleconferencing is that of acoustical conditions in conference rooms with more than four people. If groups are kept small, acoustical problems, while annoying, are manageable. The biggest hurdle in audio teleconferencing might be the issue of order of speaking. In face-to-face communication, visual feedback indicates when someone is almost finished speaking and even helps to identify others who are waiting to speak next. In audio teleconferencing, it is not easy to establish speaking order, and sometimes identifying who is speaking is problematic. Though simpler and less expensive than video systems, audio conferencing may require a little more discipline among its users; they will have to pay closer attention to who is speaking and what is being said.

Rice (1984) defines computer conferencing as "a computer-facilitated mechanism for recording and using a textual transcript of a group discussion over varying lengths of time, by group members who may be geographically dispersed and who may interact with the transcript either simultaneously or at times of their own choosing" (Rice, 1984, p. 131). Computer conferencing is generally less expensive than the telephone and TELEX, and perhaps even less expensive than audio teleconferencing (Johansen et al., 1979).

Today, computer communication networks are used for group problem solving and forecasting, consensus development, coordination and operation of group projects, and sharing ideas and jokes (Hiltz, 1982; Tapscott, 1982; Vallee, Johansen, Lipinski, & Wilson, 1977). Thus, computer-mediated communication is a key component of the emerging technology of computer networks. In computer networks, people can exchange, store, edit, broadcast, and copy any written document. They can send data and messages almost instantaneously, easily, at low cost, and over long distances (Kiesler, Siegel, & McGuire, 1984). Most importantly, the medium has a memory. Participants can log in at any time to receive waiting messages, read the latest version of a document or work on a manuscript others have edited (Hiltz & Turoff, 1978; Rice, 1984; Williams, 1977). Thus, computer conferencing systems provide shared files. Basic facilities include text editing, storage and printing capabilities, along with messages and conferences, which are either public or private and which may involve specific individuals, a formally defined group, or anyone with access to the system.

Computer-Mediated Communication Effects

Computer-mediated communication differs in many respects from more traditional communication technologies. For example, it has the speed and energy efficiency, but not the visual or aural feedback of face-to-face and audio communication. Experiments using problem solving tasks to compare voice media (i.e., face-to-face, audio-video, audio only) with written media (i.e., teletyping, remote handwriting) found voice media to result in faster solutions (Chapanis et al., 1972; Johansen et al., 1979; Kreuger & Chapanis, 1980; Weeks & Chapanis, 1976), although there were little differences in the accuracy of the solution achieved. Not only can the verbal channel transmit more words per time unit for a given individual, but the mechanics of the written channel necessarily create delays (such as typing speed, transmission speed, and read-out speed; see Hiltz & Turoff, 1978). No differences were found between the two written media and the two voice media. It may be that problem solving tasks do not require nonverbal feedback in determining the task outcome (Williams, 1977).

For decision making tasks in which groups must come to a consensus via computer or face-to-face media the finding is the same: It takes less time to arrive at a decision in a face-to-face group (Siegel, Dubrovsky, Kiesler, & McGuire, 1986; Hiltz, Johnson, & Agle, 1978). When the experiments have time limits, computer-mediated groups form less consensus than face-to-face groups, and agreement on the group's decision tends to be lower in computer groups (Kerr & Hiltz, 1982). Since agreement tends to be lower in groups communicating via computer, and because there are fewer sanctions or effects on deviants in these groups, members can "hold out" for their decision, though the level of agreement is not necessarily related to the quality or accuracy of the decision (Rice, 1984).

The lack of nonverbal feedback and affective cues in computer-mediated communication affects decision making outcomes; by removing "irrelevant" considerations in decision making, such as status, charisma and prejudices, there may be less errors in judgment. In one experiment, for example, computer-mediated groups were relatively more task oriented and made more decision proposals than face-to-face groups (Siegel et al., 1986). In the same experiment computer-mediated groups chose riskier alternatives than groups meeting face-to-face. There also tends to be greater equality of participation in groups using computer conferencing as compared to face-to-face groups, allowing for more diverse and possibly more correct decisions. Thus, it may be that for group decision tasks in which group members have reason to explore minority opinions, computer-mediated communication will take longer because feedback is reduced. However, an audio link combined with electronic mail in the same facility would decrease the differences between electronic communication and face-to-face communication, if only to increase the amount of feedback (e.g., Chapanis, 1976; Kiesler et al., 1984). Other group decision tasks, however, in which group members simply have to hear a correct answer to accept it, will probably take less time when communicating by computer.

Most existing discussions of computers focus on the advantages of computer-mediated communication for work: fast and precise information exchange, increased participation in problem solving and decision making, and reduction of "irrelevant" cues (Linstone & Turoff, 1975; Martino, 1972). If, for example, minority opinions can enhance performance, then groups could be more effective when using computers to communicate (Kiesler, Siegel & McGuire, 1984). However, computer-mediated groups might also be disorganized; they might have trouble reaching consensus if the "correct" solution is not obvious; they might not be accurate and fast problem solvers.

A long-term series of studies was conducted at the Johns Hopkins University by Chapanis and others (cf., Chapanis et al., 1972; Chapanis, 1976; Ochsman & Chapanis, 1974) which constitute a major work on human factors in telecommunications and teleconferencing systems. The goals of the program were to discover (1) how people naturally communicate with each other when they are required to solve problems of various kinds, (2) how interactive human communication is affected by the machine devices and systems through which people converse, and (3) what significant system and human variables affect interactive communication. Results of these studies are summarized below (Chapanis, 1976):

1. Problems are solved significantly faster in communication modes that have a voice channel than in those that do not.

2. Modes of communication that have a voice channel are much wordier than those that do not have a voice channel.

3. Face-to-face communication is wordier than voice only.

4. Oral communication is highly redundant.

5. Communicators are much more likely to take control of a communication system (that is, to interrupt) if the system has a voice channel.

6. In tasks requiring the exchange of factual information to solve problems, only about half a communicator's time is spent in actual communication, that is, in sending or receiving information. The rest of the time is spent in doing other things, for example, making notes, handling parts, or searching for information.

7. When the task involves the exchange of opinions and argumentation, as much as 75 percent of a person's time may be spent communicating. However, at least 25 percent of a communicator's time is still spent in other activities, for example, making notes and searching for information.

8. The greater the level of sophistication of the communicators, the more quickly they are able to solve problems.

9. Typing skill does not appear to be a significant factor in the kind of communication with which we are concerned.

Much of the teleconferencing literature deals with the topic of high-level meetings, and considers issues in creating the equivalent of a moderately large multi-point video conference (cf., Orlansky, 1963; Bavelas, 1963, Bavelas, Belden, Glenn, Orlansky, Schwartz and Sinaiko, 1964). Similarly there is a segment of the literature that deals with engineering issues associated with the hardware and communications for enabling such conferences (cf., Aircraft Armaments, 1963; McDermott Associates, 1982; Vest, Olson, Jones and Clements, 1984).

A research group at Xerox PARC (Stefik, Foster, Bobrow, Kahn, Lanning and Suchman, 1987) has been investigating computer support of collaborative problem solving in face-to-face meetings. Their thesis is that most computer systems aid the work of separate individuals but not their work in groups. A laboratory called COLAB is evolving which consists basically of a number of personal workstations linked with a large touch-sensitive screen and a stand-up keyboard. They introduce the notion of a multi-user interface and have been developing and testing a series of tools for collaboration:

- o Boardnoter -- closely imitates a chalkboard but allows input from several workstations, provides legible fonts and drawing aids, and permits saving work between meetings.

- o Cognoter -- provides means for organizing ideas to plan a presentation in brainstorming-organizing-evaluation phases.

- o Argnoter -- provides for the consideration and evaluation of alternative proposals in propose-argue-evaluate phases, and attempts to avoid common problems: owned positions, unstated assumptions, and unstated criteria.

These tools are based on a statement of desirable meeting processes tailored for specific objectives, and an understanding of some of the common impediments to meeting success. The system includes means to identify

work-in-progress and to resolve conflicts between the desire of the participants to manipulate the same display objects. Individual pointers are displayed only on request to avoid the distraction of multiple pointers. The database architecture is a major development issue to ensure that users do not conflict in making data base updates and to ensure that all use the same data at all times. Although this effort is devoted exclusively to face-to-face meetings it is clear that the approach is applicable to computer augmentation of the different processes involved in military teams (given a better understanding of these processes) and that such augmentation may alleviate the effects of distributing the team.

Experimental Design Considerations

In the remainder of this literature review we will present a wide range of information which can be of value when designing specific experiments. This information is presented under the rubrics of task classification, factors influencing group performance, and measurement.

Task Classifications

A variety of tasks using computer-mediated groups have been identified. Tasks generally fell into one of four categories: problem solving, choice dilemma, discussion, and games. These tasks are listed in Table 3. One problem-solving task involved urban traffic planning in a large city (Hirokawa, 1983). Weighing the acceptable level of risk in a business opportunity (Hiltz, Turoff, & Johnson, 1985) is an example of a choice dilemma task. Group discussion of an attitude questionnaire (Cvetkovich & Baumgardner, 1973) and a tactical battlefield simulation (Lyman, 1986) come under the categories of discussion and game tasks respectively. A good, brief overview of all of the variables that are relevant to computer-mediated group communication is given by Price (1975, Fig. 4). He identifies media, task, interaction, individual, and group variables.

Table 3

Summary of Representative Group Tasks, Structure, and Variables

		Variables	
Tasks	Structure	Independent	Dependent
Problem solving	1-5 peers in	Communication mode:	Performance/
Choice dilemma	-Cooperation	-Face-to-Face	Outcome
Discussion	-Coordination	-Computer Mediated	Time
Games	-Conflict	-Other audio/visual	Behavior
		Task related:	Process
		-Feedback	Group
		-Complexity	cohesiveness
		-Information type &	Choice shift
		organization	Linguistic
		Group related:	variables
		-Size	Attitudes
		-Interaction	
		-Organization	
		-Attitudes	

A survey of additional ways of classifying tasks can be found in Dyer (1984). She cites five schemes (1-5 below) that classify tasks according to the behavioral, personal, and sub-task specific requirements of individual tasks.

(1) Altman (1966): behavioral acts, behavioral requirements, intrinsic task properties,

(2) Hackman (1969): task as a behavior description, task as a behavior requirement, task qua task, task as an ability requirement,

(3) Fleishman (1975), Wheaton (1968): behavior description, behavior requirements, task characteristics, ability requirement,

(4) O'Brien (1967): task-person (responsibilities), task-person (abilities), task-task, task organization,

(5) Roby & Lanzetta (1958): group input and output at the description and distribution levels, critical demands, task input, task output.

Another way of classifying tasks is by the nature of interaction among the team members, referred to as Group Structure in Table 3. Team members, in most studies, cooperate to achieve a group solution or consensus. Other studies have used coordinated tasks where each team member performs a separate sub-task (Lyman, 1986) and conflicting tasks where team members have individual goals in addition to or in place of team goals (Weeks & Chapanis, 1976; Williams, 1977).

Factors Influencing Group Performance

Research results reveal quantitative and qualitative differences between face-to-face and computer-mediated decision making groups. Some factors that may be responsible for the differences are (Dyer, 1984):

- Feedback on performance (Bowen & Siegel, 1973; Johnston & Nawrocki, 1966; Nebeker, Dockstader, & Vickers, 1975)--as with individual behavior group behavior is strongly affected by reinforcement and performance feedback, although the options are more numerous and complex.

- Group stability (i.e., personnel turnover) (Eaton & Neff, 1978; Forgays & Levy, 1957; Horrocks, Heermann, & Krug, 1961; McDaniel & Dodd, 1972)--turnover reduces performance, with impact caused by changing crew duty positions, changing key personnel who interact the most, and by introducing more untrained individuals.

- Team coordination and cooperation (Banks, Hardy, Scott, & Jennings,1975; Hewett, O'Brien, & Hornik, 1974; Kabanoff & O'Brien, 1979; O'Brien & Owens, 1969)--task structure can create differences in group effects, for example, for coordination tasks performance relates to the summed abilities of group members, and, collaborative structures may hinder performance.

- Disparate ability levels of members (Tziner & Eden, 1985)--crew performance is affected in a non-additive manner by differences in member's ability.

- Size of the team (Havron & McGrath, 1961; Kidd, 1961; Kinkade & Kidd, 1959)--group productivity is not a linear function of group size, and at some point additional crew members cause a performance plateau.

- Work structure/distribution (Johnston & Briggs, 1968; Kidd & Hooper, 1959, Lanzetta & Roby, 1956)--with constant team size, increased team load decreases team performance, but this effect varies with work distribution and requirements for team coordination.

- Communication structure (Leavitt, 1951; Guetzkow & Simon, 1955)--performance may be affected by communication network and organizational structures.

- Group planning (Hackman, Brousseau, & Weiss, 1976; Shure, Rogers, Larsen, & Tassone, 1962)--the importance of group planning and discussion is supported by small group studies, but depends in part on the task and need for information exchange.

These factors should be considered in the design of new experiments to attempt to control for these effects or as primary experimental treatments.

Group Measurement

The basic method for studying team processes is observation and recording of team behavior. Other methods include communication recording and interviewing team members. One may make use of current computerized linguistic analysis tools (cf., Miller & Chapman, 1985). Techniques such as timelines and flowcharts (e.g., Operational Sequence Diagrams; cf., Crowe, Hicklin, Kelly, Obermayer, & Satzer, 1981; Kurke, 1961) have also been used to study group processes. Rule-based models, through the detailed knowledge base which is developed from knowledge acquisition with team members, provide extensive description of team processes (Obermayer, Slemon, Johnston, & Hicklin, 1984). Team performance has been measured by proficiency ratings and outcome time-to-complete, accuracy and errors (Dyer, 1984). Further, care must be taken to see that the variables studied tap the relevant dimensions of the task. For example, time to reach a decision is often recorded, but, its utility may be of little value in low-stress tasks where time is not critical (Williams, 1977).

Implications of Previous Research

Some form of computerized network should be considered for possible enhancement of distributed command and control systems. At this point in time, video and audio teleconferencing by themselves do not seem adequate and text-based communication systems alone may not be adequate for military problem solving tasks. Additionally, system design solutions might include

graphical displays, aids for uncertain information, standard protocols for communication, training programs, contingency plans for coping with predictable system failures, and terminology for coordinating diverse units (Fischoff & Johnson, 1985).

The formalized structure of military C2 systems may also affect computer-mediated communication. For example, in formal systems, group members share common goals, common experience, and a well established communications link. Having highly shared models of the decision task can reduce information overload by dividing information-processing responsibilities, and some mistakes can be avoided by having someone to check one's work. However, having someone who thinks similarly in the system may just mean having more than one person prone to the same judgmental difficulties (Janis and Mann, 1977). Such problems arise because frequency of interaction can create a perception of completely shared models, when sharing is inevitably incomplete. Computer-mediated communication links between individuals (or units) with deeply-shared common experience might allow them to acquire different information and formulate somewhat independent perspectives, thereby reducing the risk of groupthink. In order to improve what has been termed "the cohesiveness of command," decision aids such as electronic blackboards and dynamic battle situation maps might be an important capability.

For the purpose of survivability, the most important and distinguishing feature of computer communication networks is its memory capability. If an individual or a whole functional line is lost in combat, it will still be possible to retrieve their information and current data analyses. Computers can also be used as decision aids. For example, it may be possible to reduce some systematic errors in judgment by forcing users to list reasons why they might be wrong before assessing the likelihood that they are right (Koriat, Lichtenstein and Fischhoff, 1980).

Kiesler, Siegel and McGuire (1984) raise six issues surrounding the introduction of electronic communication technologies:

(1) Time and information processing pressures. Does easy, rapid communication change the distribution or the quantity or the timing of information exchanged? If information exchange is faster, for example, people might expect immediate responses.

(2) Absence of regulating feedback. Does communication lacking nonverbal behavior give group members enough information to coordinate communication? Electronic communication may be inefficient for resolving such coordination problems as telling someone you know the solution to a problem.

(3) Dramaturgical weakness. How will people compensate for the absence of nonverbal cues in electronic media? Hearing someone's voice or looking someone in the eye changes negotiation and bargaining processes (Carnevale, Pruitt and Seilheimer, 1981).

(4) Few status and position cues. As group members participate more equally on a computer, how will the role of status be perceived? Although in the mil..ary, status or rank of officers is not easily ignored, it still raises an important question: How will military leaders be perceived and "spoken to" during electronic communications?

(5) Social anonymity. Is electronic communication impersonal and depersonalizing? Because electronic communicators must imagine their audience, messages are depersonalized, inviting stronger or more uninhibited text and more assertiveness in return.

(6) Computing norms and immature etiquette. Because there are few established rules for computer communication, how do people develop a social communication network structure? Do they import norms from other technologies or do they develop new norms?

This review of previous research on decision making with respect to groups and teams has identified potentially useful variables for current and future research on distributed military teams. The potential list is enormous but priority issues must be carefully selected (see Appendix A for a succinct tabulation of a comparison of selected research). The goal of subsequent sections of this paper will be to further delineate relevant variables, and derive testable hypotheses about the effects they may have on military teams.

SECTION III

DISTRIBUTED MILITARY STAFFS

Introduction

Although the literature review shows that many attempts have been made to describe the distributed effects on personal relations, group processes, decision making, and information processing, little of the literature or experimental work specifically addresses the military staff and its decision making and problem solving process. Distribution of units, staffs and functions is a common attribute of military staffs and units. This distribution provides for survivability of personnel and function, makes use of the available space on the battlefield, and provides the commanders the flexibility to exercise their command functions from the most advantageous position on the battlefield. Advances in communication technology and acceptance of the computer as a military tool provide an opportunity to further distribute the decision making process and the opportunity to address the use of technology in the Command and Control (C2) system of today and of the future. The intent of this section is to outline the purpose, structure, decision making processes and the interaction of staffs as related to distribution, and to identify issues that are unique to the military staff.

Purpose of Military Staffs

The military staff, or the Command and Control (C2) system, allows the commander at all levels to deal with a variety of tasks. The system facilitates the cooperative and coordinative endeavors of many people, the integration of numerous complex equipment systems and a sensible division of work. To assist the commander in discharging his responsibility for command and control of organic, assigned and attached forces, the commander and staff operate within a command and control system that consists of three interrelated components: organization, process and facilities.

Command and Control Organization

This organization, generally outlined in FM 101-5 and tailored by the commander, allows the commander and staff to accomplish the mission. This organization includes the role and relationships of the staff, the authority and responsibility of the staff, and a functional grouping of staff sections.

Command and Control Process

This process facilitates decision making and outlines procedures used by the staff. This process allows for a systematic, procedural method of accomplishing the mission. These procedures and techniques allow the commander and staff to acquire information, decide upon necessary action, issue instructions and orders, and supervise the execution of actions specified by the instructions and orders. These procedures include record keeping, reporting systems and briefings that support the decision making process.

Command and Control Facilities

These facilities include the command posts, tactical operations centers, rear area operations centers, and the supporting automation and communication systems. They provide for the processing and transmission of information and orders necessary for effective command and control.

The military staff is organized as a single, cohesive entity to assist the commander in accomplishing the mission. The staff is a professional team that operates within a generally known situation or context. The staff has common goals, is subject to a common history of preceding events, and shares a common experience. Staff members know not only their own roles and functions, but the roles and functions of the other staff members. The staff establishes and maintains a high degree of coordination and cooperation internally and with staffs of other units.

Staff officers are assigned functional areas of interest and responsibility for accomplishing staff actions. This functional responsibility allows the commander to rely on a single staff agency for advice and assistance for a particular mission or action area, provides a single staff agency for coordination with other staff sections and units, insures that all command interests receive staff attention, and allows staff officers to focus their attention to a definable portion of command interests.

The authority of the staff officer is delegated by the commander within functional areas of interest and responsibility. This authority, generally, allows the staff officer or section to take the necessary action, utilize resources, and exert a degree of influence over other staff sections necessary to accomplish the mission or task. This influence is instrumental in achieving a staff consensus so that a common direction is pursued by the various staff sections. The staff officer's authority should not be construed as command authority, rather it is coordinating authority. The authority vested in the staff officer may change from situation to situation, depending upon the immediacy and importance of the assigned task and upon the desires of the commander. Along with the authority to accomplish a task comes the responsibility for the task. This responsibility includes task completion, quality control, and the identification and tasking, on the commander's behalf, of assets.

The staff assists the commander in decision making by acquiring, analyzing and coordinating information, and most importantly, by presenting essential information to the commander with a recommendation so that he will be able to make the best decision. What the staff does with the assembled information is of crucial importance to the function of staff operations.

The Staff:

- o Facilitates and monitors the accomplishment of command decisions.

- o Provides accurate and timely information to the commander and subordinate units.

- o Anticipates requirements and provides estimates of the situation.

- Determines courses of action and recommends a course of action which will best accomplish the mission.

- Prepares plans and orders.

Distribution of the C2 System

The C2 system operates from geographically separated locations. These locations, or command posts, contain the appropriate staff officers to perform the functional tasks assigned to a particular command post. These command posts are organized to facilitate the command and control processes, provide survivability, and to allow the commander and staff to exercise their functions from the most advantageous position on the battlefield.

Command Posts (CPs) are designated as tactical, main, alternate and rear. CPs are established to assist the commander in command and control functions of combat operations. As a contingency, CPs must provide command and control for the entire battlefield. Divisions normally establish a tactical CP, a main CP, and designate an alternate CP.

Tactical CP. When established, the tactical CP is the forward echelon of the Division Headquarters. The tactical CP normally is manned by staff elements of the G2, G3, fire support, tactical air control party, air defense artillery, and combat service support staff sections (Figure 1). The G3 is normally found at the tactical CP, and has staff responsibility for the actions of the tactical CP. The tactical CP controls current operations, develops combat intelligence of immediate interest, controls manuever forces, controls/coordinates immediately available fire support, coordinates and manages airspace and forward air defense operations; and communicates combat service support requirements to the main CP.

Main CP. The main CP, located to the rear of the forward deployed force, operates under the control of the Chief of Staff. The main CP supports those staff activities involved in sustaining current operations and in planning for future operations (Figure 2). All staff sections are represented at the main CP. The main CP functions to sustain current operations, collate information for the commander, acquire and coordinate combat support, provide reports to higher headquarters; provide a focal point for development of all source intelligence, coordinate requirements for rear area operations and conduct planning for future operations.

Although the specific tasks or responsibilities for the main and tactical command posts are different, they are functionally redundant. If one of the command posts was unable to perform its particular function, the other command post could perform the function in an emergency. This functional redundancy is reliant upon information and activity history. The alternate command post, normally the artillery headquarters, is also required to be able to accomplish the tasks of the tactical command post in an emergency. Regardless of where the emergency tasks are performed, functional redundancy, information and historical data are required for successful task accomplishment. Multiple command posts increase survivability of the force as a whole, but may not have access to all of the information necessary if required to accomplish tasks for other command posts.

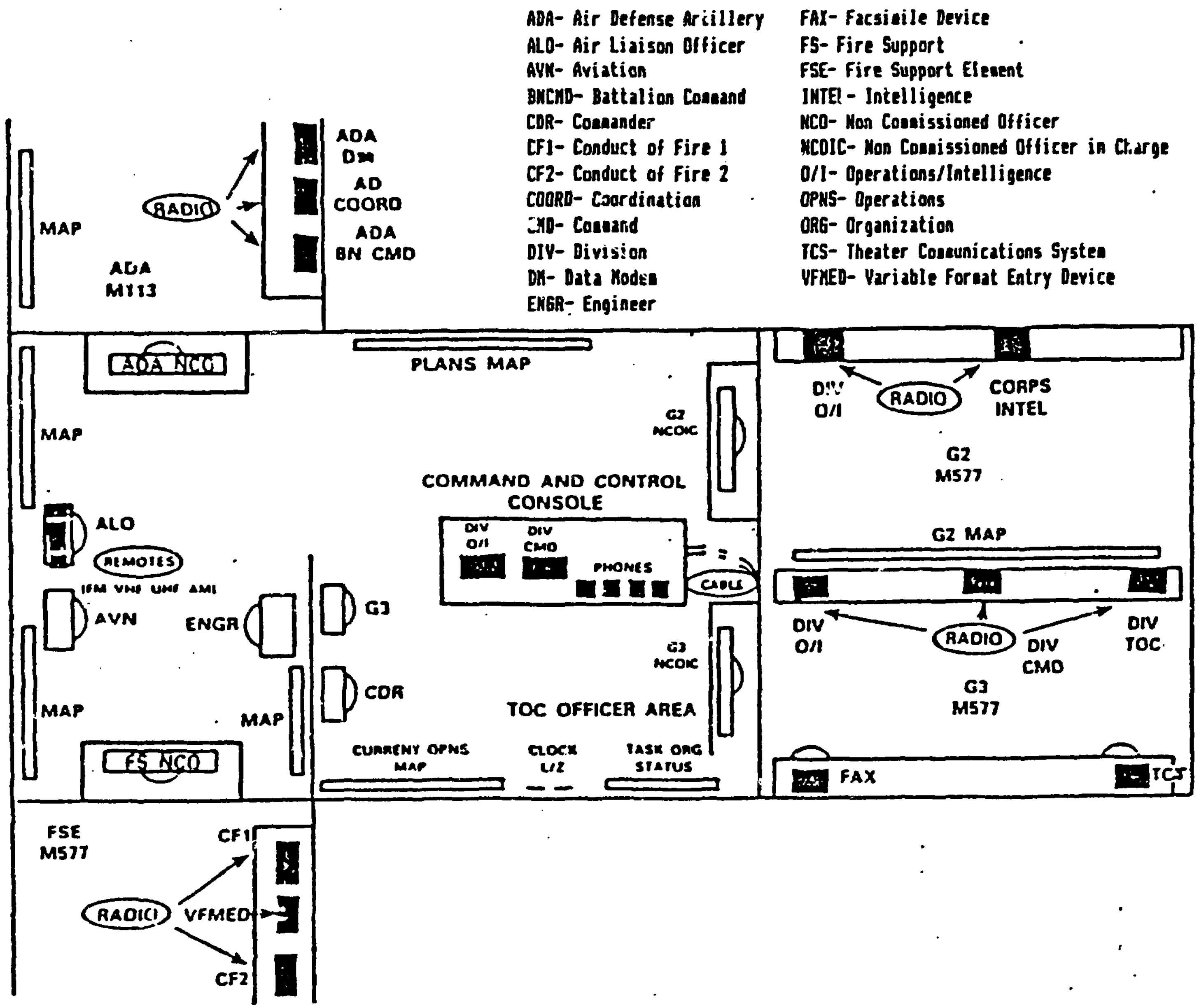

Figure 1. Division tactical command post.

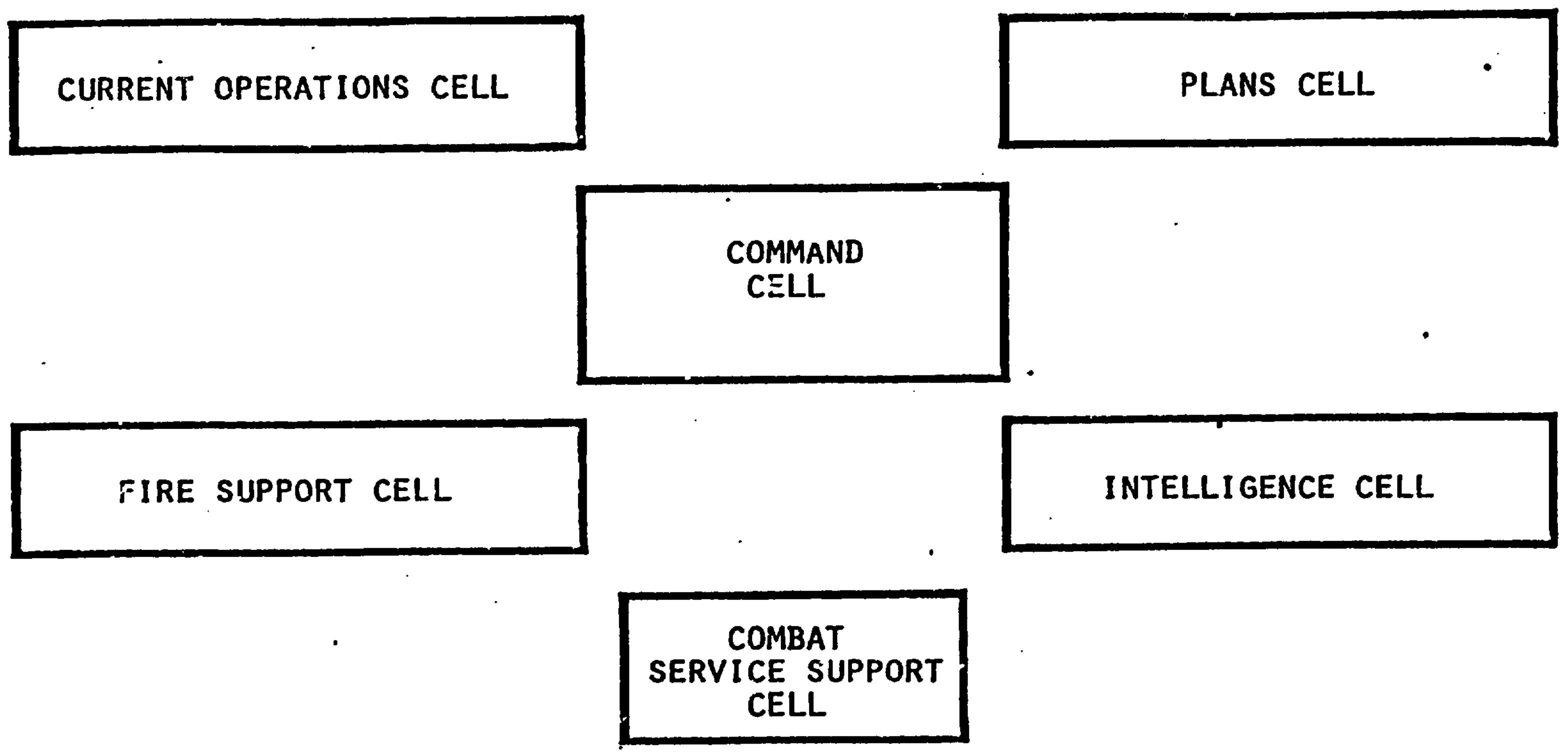

Figure 2. Division main command post.

Command Post Operations

As in all military situations, decision making in CP operations is marked by commanders making decisions and staff officers and sections providing critical information and recommendations. The degreé and extent of operational authority given to staff officers is clearly defined by the commander, and is always in consonance with staff responsibilities. Flow of information is key to the decision process, and is imperative to support the coordinative aspect of staff work. Information must flow within a particular CP, as well as to the distant CP and to the units being controlled by the command.

In order to standardize and optimize staff activity, CPs are also organized along functional lines. Those members of the tactical CP are concerned, primarily, with the immediate battle. Their responsibility is one of execution vice planning. They monitor combat activities, change priorities, or recommend priorities, commit available forces, and generally prosecute the ongoing battle. Conversely, the members of the main CP are charged with the responsibility of maintaining the force and planning for the future battlefield. Future in this sense may be as soon as 12-24 hours or some greater time in the future.

It is necessary for various staff officers and sections to communicate to accomplish their mission. This communication may be external to the CP or internal to the CP. The fact that units and staffs are deployed throughout the battle area requires external communications. Various units and unit staffs must communicate on numerous staff activities; orders and reports routinely flow from location to location. To minimize external communication requirements, the various command posts are organized to facilitate functional responsibility and coordination requirements, allowing accomplishment of tasks in one CP without the need to communicate or coordinate with the other CP. Ideally, the need to actively coordinate for a particular action will not require external communication. This ideal is a consideration when organizing the staff and command posts for combat. Not only is staff representation required at each of the command posts, but functional organizations are created within each of the command posts that cross staff lines.

Control and coordination of operations occur at the tactical command post, the main command post and the support area. To better understand how these functions are managed, a brief discussion of selected command and control staff functions is provided below.

Fire Support

Fire support is controlled at both the main and tactical command posts. In the conduct of the battle, the tactical command post is responsible for coordinating the use of all immediately available, or near immediately available, fire support means. The tactical CP also advises the commander and staff on all current fire support operations, capabilities, and status, and evaluates additional fire support requests. The fire support functions performed at the main CP consist of planning and coordinating the use of conventional artillery, nuclear and chemical fire, insuring that organic and

attached nuclear capable artillery units remain correctly positioned; coordinating requests for additional fire support; preparing the fire support portion of plans and orders, to include the preparation of the fire support annex, and advising the commander and staff on all matters pertaining to fire support operations.

Tactical Air Support

Air Force tactical air support control functions are divided among the main CP, the tactical CP and the support area. The Air Force element at the tactical CP normally coordinates the use of immediate fighter requests. They may also provide direction and assistance for other immediate requests. The element at the main CP has responsibility for coordinating for the use of planned air assets and assists in the determination of sortie requirements for fighter, reconnaissance, and airlift. The element in the support area coordinates actual airlift assets with airlift requirements.

Airspace Management

Air defense and airspace management functions are accomplished at both the main and tactical CP. The airspace management element at the tactical CP coordinates the immediate requirements for the use of airspace and air defense operations in the forward area. At the main CP, the airspace management element provides for air defense in the rear area, plans for future use of airspace and coordinates the immediate use of airspace in the rear areas.

Intelligence

The intelligence element at the tactical CP provides all-source intelligence of immediate concern to the commander and generates targets for immediate engagement and attack. The majority of the intelligence production effort is conducted at the main command post and involves the functions of planning, collection, management of resources, and analysis of information, and the production and dissemination of the finished intelligence products.

Civil-Military Operations

CMO functions are the staff responsibility of the G5 section and are performed from the main CP and support area. They include those actions that address the relationship between the military forces, civil authorities, and the population in the area of operations. They also include actions in which psychological operations techniques are used to support operational planning. These functions impact on and require coordination with all staff sections to insure total integration into all tactical plans and orders.

Combat Service Support

Combat service support functions are controlled at the main CP and in the support area. The G1 and G4 normally operate from the main CP. A combat service support representative(s) at the tactical CP keeps the

commander and staff at that location up to date on the current situation, and provides informational updates to the G1 and G4, at the main CP, on the current battle and changes in priority.

The foregoing discussion on staff responsibilities and functions in relation to CP location is only a partial representation of the functional staff responsibilities. The discussion serves to highlight the fact that the main CP is generally responsible for planning and sustainment of the force, and that the tactical CP is responsible for current operations and for communicating the desires and changing priorities of the commander to the main for consideration in planning and sustainment. The discussion states that coordinating staff duties may be required at more than one location, and that the coordinating staff officer (G1-G5) must organize his staff section in such a manner that all responsibilities are met regardless of location. Each of the CPs contains functional groupings of staff officers who have partial responsibility for the conduct of various functional staff activities in support of ongoing operations. These groupings may be formal or informal, may be permanent, semi-permanent or ad-hoc, as the situation requires.

Communication

Communication is often the key to successful staff work. As previously discussed, staff sections must coordinate, formulate plans and orders, monitor the execution of plans and orders, monitor the ever changing battlefield, and have an impact on that battlefield. To successfully accomplish the mission of the command, the staff must have a method to communicate. These communications will be internal to a CP, external to another CP, and will be external to the command to another unit's command and control organization.

Within a particular CP, the majority of tasks must be internally coordinated with staff counterparts. This coordination normally requires face face communication, using shared maps, overlays and other displays, and t sharing of data. Often various staff officers work in functional groups to solve the staff problem. The task they perform will normally be a sub-task of a major staff requirement. For example, the Fire Support Element may have to make a determination of the number of artillery tubes available for a particular operation. This sub-task would be accomplished by reviewing the available data and reports. This information would then have to be passed to another staff officer who determines ammunition requirements for a particular operation. A series of sub-tasks of this nature would be accomplished within a functional grouping of staff officers. Their completed work would be forwarded to another staff section or functional group for consideration and inclusion into the plan as a whole. At some point in the process the major sub-tasks are all completed, necessary coordination by the responsible staff section is complete, and the particular action is ready for execution. This execution may take place through a written order or plan, an oral briefing, or a verbal order.

At times it is necessary to communicate about a staff action with a staff counterpart who is located at another CP. The necessary data, information, guidance or priority may have to be passed to another location or received from the distant location. Part or sub-task accomplishment does not always take place within a face-to-face functional grouping; the responsible staff officer may have to rely on the distant location to accomplish the necessary sub-task. Plans, orders and reports are routinely transmitted to the distant location. These distant locations may be the other CP locations, and/or the command and control nodes of higher, lower and adjacent units.

To fully appreciate the communication requirement, it is necessary to address the number of command and control nodes on the battlefield that have communication links. A division may control 3-5 brigades, each with two command posts and each controlling 3-5 battalions. Taking this into account and adding in the artillery units, combat support units, and the combat service support units; the division may have as many as thirty command posts that require command and control communications. The division CPs will not directly communicate with all of these, but will have to communicate with higher and lateral headquarters.

Role of the Staff Supervisor

The staff supervisor is responsible for task accomplishment, quality control, conflict resolution, and for insuring that the requisite coordination required by the nature of the task takes place. Within a staff section there are several layers of supervision. The supervisory responsibilities may be assigned: along functional lines, dependent of task, by rank, by location, or combinations of these factors. The supervisor has the responsibility of insuring completeness of the assigned staff task or sub-task within the time available. Successful supervision requires that the supervisor have a way of exercising control over and interacting with the personnel he is supervising. This control or interaction may be face to face or through communication.

Geographic Separation of C2 Nodes

Current Node Separation

The command and control (C2) nodes on today's battlefield are distributed. This distribution allows the commander and his functionally organized staff to see and feel the battlefield. These nodes are placed to enhance command and control functions, provide a degree of survivability and allow shortening of the operational and command link. Distribution today is primarily accomplished by placing certain functions well forward so that the commanders and their staff are in position to exploit communications, rapidly coordinate, in some cases face to face, with subordinate units and allow the operational activities to take place removed from the sustainment activities. This distribution, coupled with functional organization of C2 nodes, allows the commander and his staff to concentrate on their responsibility for fighting.

This distributed system must rely on communications to share information, issue plans and orders, receive feedback, allow coordination among various nodes, and allow collaborative action in the formulation of plans and orders. Until recently this communication has been provided primarily by radio, wire and couriers. As computers become more prevalent in the command and staff nodes, the ability to share information using computer links will affect the way that C2 nodes communicate. The computer will highlight a new set of communications issues that deal with computer mediation and augmentation of communications and staff functions. These issues will be as mundane as determining time-sharing priority to the more sophisticated issues of determining the best form of communications. The form of communications may be message sending, file sharing, graphic interaction, mail box, among others.

C2 distribution is a normal phenomena of the battlefield. Communication support for that distribution has always been a problem that requires solution. C2 distribution, coupled with computer-mediated communications, and the ability to augment staff functions by using computers raises issues that need to be addressed. Adding the capability of the computer to the existing C2 nodes may affect the functional activities of staffs, may affect the traditional responsibilities of staffs and may affect the staff processes that exist to assist the commander in decision making. The possibility of rapidly disseminating information, plans and orders does exist with the computer, and may allow a new standard of coordination and collaboration to be developed to support the decision cycle. The issues of how to use the computer capability to communicate and the issues of what to communicate and in what form have a direct relationship with an evolving tactical decision making process.

Future Node Separation

Just as manuever units are required to operate in a non-linear manner for successful conduct of the AirLand Battle, it is imperative that the associated command and control systems (C2) think, act and distribute information in a non-linear and non-traditional fashion. It will be necessary to provide information and orders to multiple units at varying operational and tactical levels, at times even neglecting the traditional hierarchy or layering of C2 nodes. The C2 system needs to be as fluid as the ever changing battlefield. With the tremendous gains made in information acquisition systems, communications and technology, the commander no longer can rely on a system that may be static and that laboriously exercises the commander and staff functions.

The roles of the commander and staff may appreciably change from the traditional description outlined in FM 101-5. Staff planning actions and commander actions may deviate from the traditional. The military decision making process and the commander and staff actions required to make and execute decisions will certainly continue to evolve. These changes will be in response to a changing environment. Never before has the C2 system been challenged in such a manner. The battle will be conducted violently, quickly and in a larger scope than ever before envisioned.

The manuever units will be expected to conduct operations within narrow windows of opportunity. These windows are anticipated to be of relatively short duration, yet present the best time to conduct operations that have a decisive bearing on the outcome of the battle or campaign. It will be the responsibility of the C2 system to support these window operations. Information must be gathered, analyzed, and distributed. Estimates must be prepared, functional coordination must take place and commanders must make decisions. These actions must be continuous and in anticipation of the opening of the window. Orders must be prepared and issued in a timely manner if the commander is to take advantage of the vulnerability window.

Information dissemination. To support the battlefield that is larger in scope and compressed in terms of time, the C2 system must have a method of locally and distantly disseminating information, coordinating between functional staff members and receiving and responding to commander guidance. Fulfilling these local requirements is primarily a problem in staff functions and interfaces. However, if the local C2 system is geographically separated, it becomes a problem of locating the appropriate staff members where they have access to their functional counterpart and access to the battle commander. In reality, since all contingencies can not be covered by staff location, it becomes a problem of communications, both graphic and voice. The requirement to provide near real time information and intelligence throughout the entire spectrum of C2 systems is critical.

If commanders at all levels are to be expected to carry out their mission, act independently, and to be decisive and bold, they must have information, the latest staff estimates and understand the guidance and decisions of the superior commander. To accomplish this task in the environment of the next battlefield, the C2 system must be capable of relaying information, orders and guidance throughout the area of responsibility. This task is complicated by four factors: 1. geographic separation of units will be very large because of the threat of nuclear weapons and based on the tactics envisioned; 2. the electronic environment will be one of confusion, lost and jammed communications, and airwaves garbled by the number of users, both friendly and enemy; 3. the tremendous amount of information available and; 4. the requirement for nearly instantaneous communications.

Reliance on communications. The successful C2 system will influence the battle through the intelligent use of coordination and communication skills and technological tools available. The C2 system that is able to rapidly coordinate, both locally and with counterpart C2 systems, on available information, provide estimates in a timely fashion, act immediately upon the commander's guidance and rapidly prepare and disseminate orders will be successful. The inability to accomplish these tasks will cause the manuever units to enter the battle in reactive rather than an active mode. These units will not have the advantage of seeing a clear picture of the battlefield and will not necessarily have the advantage of clearly understanding the situation and the commander's intentions and stated mission.

Coordination and information distribution seem to be the key to successful staff/commander actions. Today's commander and staff, normally coordinate face to face using hard copy of information available. The next battlefield will not allow that luxury. The C2 systems will be separated by great distances. This separation will certainly be apparent from unit to unit, but will also be true within a particular unit and separation may occur within any one C2 node. To be able to coordinate and distribute information, the various C2 nodes must rely on communications and a technology that allows visual display of data. These data not only must be displayed but must be able to be manipulated, described, modified and "gamed." All of these things have to take place over great distances, among several locations and done in near real time.

Various displays and technologies could be used to support the C2 system. Map displays with symbology, data lists and estimate and action files are just a few examples. The key is to determine the best method or methods of presenting data and determining the various modes to be used to manipulate and describe the display for multiple users.

Potential for computerization. The battle commander and his staff, in future conflicts, will find themselves in self contained C2 modules. These modules will be equipped with the latest secure communications equipment, will have real-time video displays and will be linked to other C2 modules. In the near future a mobile subscriber equipment (MSE) communications system may be fielded. This cellular, area communications system will provide the battle commander with a survivable, mobile capability to transmit and receive voice, data and facsimile products in a secure mode. Automatic routing/rerouting capabilities will be included in this cellular system. To optimize the capability of these C2 modules, user friendly interfaces must be developed, and operational and communication issues must be resolved to provide the battle commander useful tools to fight the battle.

SECTION IV

SELECTED ISSUES

Selected Military Staff Issues

Understanding that tomorrow's battlefield will require greater separation of C2 nodes to enhance survivability and to support the operational activities of maneuver units, it is necessary to address several issues that will affect the way C2 nodes or systems are distributed and separated on the battlefield. The following is a discussion of issues that may arise as a result of distribution and computer mediation.

Performance

The performance of individual staff officers and functional groups may be affected by distribution and by computer mediation. This affect may, in some cases, be an increase of efficiency and in others a decrease. Two areas of performance may be affected:

Response time. The amount of time to accomplish a given task may increase for an individual or a group when separated from other staff counterparts; however, this may be mitigated by advantageous use of the technology available.

Workload. The capacity to perform greater workloads may be required when staff sections are further distributed; however, use of computer-mediated communications and use of the computer as a tool may increase the capacity for work.

Survivability

Survivability of nodes must certainly be addressed; and this will be accomplished through primarily passive means. C2 nodes will be separated by distance, both laterally and in depth. Techniques of cover and concealment will be used, and steps to limit the electronic signature will be taken. The commander, however, must also address the survivability of function. Presently C2 nodes are organized to optimize the functional capability of the staff in a particular location, and a certain amount of redundancy is available at another C2 location. If C2 nodes are further distributed or separated, a redundancy of expertise, function and information will be required at more locations. Although separation enhances survivability of the force as a whole, it does not necessarily enhance survivability of function, expertise or information.

Degradation

The distributed system must allow for degradation (loss of nodes, communications, and information). These losses will be a result of enemy activity, operational tempo, and system failures. This degradation must be anticipated, planned for and factored into any decisions made about distribution of the C2 system. Graceful degradation must be provided for; functions must not be totally destroyed, information must not be lost, and

the ability to coordinate, collaborate and provide control and influence must not be negated. This system must accommodate a redundancy of staff personnel, functional expertise and information. The command and control system must have the capability to create a history of information, action and tasks.

Supervision of a Distributed Staff

The commander and principal coordinating staff officers will have to increase their span of control. Presently these individuals are located with immediate access to staff members that perform the activities necessary to accomplish the functional staff task. The distribution of C2 nodes will spread the expertise, functions and information to more locations. The C2 system must allow the commander and C2 system supervisors to increase their span of influence and control.

Potential Augmentation of Staff Processes

Technological advances in computers and communications may alter the way that staffs accomplish tasks. The potential for information processing is limitless. This potential, if exploited, may change the traditional roles within the staff. Information gathering, processing, analysis, and sharing conceivably could be streamlined to the point that the computer is truly a tool that assists the staff officer and augments the staff process, while accomplishing task specific work.

Impact on Other Work

The staff officer of today is often hard pressed to accomplish all of the tasks assigned in a timely manner. This is especially true in an environment that is stressful and time sensitive. The assigned operational staff tasks are accomplished, however, routine work of a housekeeping nature may suffer. As the staff officer is augmented by technology, his capacity for other work may change. Assignment of routine tasks may be handled in a more equitable manner and routine tasks may be dealt with automatically, using only a portion of the available computer and communications means.

Communications

Distribution will increase the communications burden. The C2 node on today's battlefield groups the personnel necessary to perform the battlefield tasks together. This allows for face-to-face collaboration and coordination on tasks assigned. Information needed to support task accomplishment is generally available at the same location as the interactors. The communications necessary to support today's C2 node allows for communication of orders, plans and information to subordinate units, provides for information and tasking flow from one command post to another, and supports the reporting system. The distributed C2 nodes will require communications to coordinate task accomplishment, transmit plans, orders, and information to subordinates, provide information and tasking from one command post to another, support the reporting system, and create a history file of actions and activities. The requirements generated by the distributed C2 system must be met by a communication system that will be

undergoing a constant erosion or degradation of capability. This degradation must also be planned for and factored into the communication system. These communication requirements may be met in various ways as shown in Table 4.

Table 4

Alternative Communication Issues

A. Nets
   1. Real time dedicated point to point.
   2. Real time conference.
   3. Mail (message)/storage and retrieval.

B. Protocol
   1. Automatic routing/rerouting of information.
   2. Determination of priority access to communication means.
   3. Level of information access and screening of information.

C. Capacity
   1. An increase in communication nets to support distributed nodes may be required.
   2. Multiple user stations may delay communications.

Staff Workstations

Technology will allow the fielding of general purpose staff workstations and task specific workstations. These workstations may contain decision aids, task specific aids, and automatic communication capabilities. The C2 system design must specify what capabilities are required in the various distributed nodes and provide the appropriate workstation to augment the staff functions.

Selected Research Issues

Based on an extensive review of previous research on group decision making, communication effects, task activities and group structure, we identified important issues to consider in examining dispersed and distributed command and control systems. In order to answer some of the questions associated with these issues, detailed empirical work is required. In this section we list a number of variables that might be useful for the further study of decision making in military staffs. We think a basic understanding of problem solving tasks analogous to military staff operations will offer a realistic framework for further study of distributed decision making systems. Therefore, a primary criterion for a variable to be considered for further study is its relevance to military staff tasks. Our aim is to provide possible experimental designs to test hypotheses on three major effects: (1) task activity; (2) computer-mediated communication; and (3) group interaction.

Task Activity Variables

Graphic displays. The majority of tasks in the military require maps, overlays and other graphical displays. Many of these tasks require shared maps. Therefore, a task analogous to military staff decision making will use graphic displays as part of the task activity to allow closer examination of group and communication effects in military-type settings.

Text-based communication tasks. Much has been studied on the role of discussion in computer-mediated groups, so it might be useful to examine the effect of text-based messages on group decision making. In these kinds of tasks, we could look at the role of persuasion, minority opinion, consensus development, and leader influence (or status), to name a few. The notion of using text-based communication tasks is appealing, since most experimental studies offer some predictions. The question we have to keep in mind, however, is what is more relevant, graphic displays or message-based systems? Ideally, a system that offers both might be the best alternative.

Decision-making versus problem-solving tasks. Tasks in the military have been described as both decision making and problem solving tasks. A staff leader might be responsible for choosing among a set of uncertain alternatives; a staff officer might use a set of rules and procedures to arrive at a correct solution to the problem. Although it may be possible to incorporate both kinds of tasks into one experimental study, it is not advisable at the outset. First, to reduce the complexity of a single experiment, we suggest either a decision making task or a problem solving task. Second, depending on the task, different hypotheses follow. Problem solving tasks would allow examination of the rules and cognitive maps used by team members, whereas decision making tasks might examine the role of discussion and presentation of ideas -- are computer printouts viewed as more credible than face-to-face briefings, for example? Focusing on problem solving tasks also enables one to study the effects of consensus development, conformity, minority opinions, and the influence of group norms.

Choice-shift tasks. The literature on choice shifts in groups argues that group judgments differ from individual judgments. The research is intriguing for understanding group process. What is it about groups that influence individual judgments, and why do computer-mediated groups differ more from their individual judgments than face-to-face groups (see Siegel et al., 1986)? If the purpose of an experiment is to assess differences in individual and group judgments, we might want to differentiate between initial and final opinions as a measure of change.

Tasks involving risk. Although one could argue that most military tasks are imbued with risk, it may be enlightening to have some element of risk explicitly stated in the task (e.g., choice dilemma questionnaires used in choice shift experiments). A risky task comparing team members' level of risk in face-to-face groups with computer-mediated groups would allow one to test the hypothesis that computer-mediated groups are riskier.

Media Variables

Computer-mediated communication media. Our primary interest is the effect of computer communication technologies on dispersed command and control systems. We have argued that computer conferencing technologies are cheaper than other modes of communication and, more importantly, they have a memory; in terms of survivability during combat, this is a most imp rtant reason for considering the effects of computer-mediation.

Asynchronous versus synchronous communication. Use of real-time (synchronous) or delayed-time (asynchronous) computer-mediated discussion should depend on the decision making task. Asynchronous discussions will facilitate longer and more leisurely exchanges; synchronous discussions are better for more immediate responses.

Uninhibited language. What effect does lack of nonverbal feedback have on communication? Are messages sent via computer communication technologies more assertive and uninhibited because group members cannot see their audience? This hypothesis can be tested by examining the degree of terseness, lack of polite qualifications, or other subtle shifts in language. Although it is expected that military personnel will not use uninhibited language, there may be qualitative differences in communication style as a result of media effects.

Communication efficiency. Are group members able to communicate data, ideas, opinions, and feelings among themselves in the least wasteful manner? It has been argued that computers offer easy and rapid communication exchange. Hence, the technology may make possible efficient exchange of task information, without some of the inefficiencies found in face-to-face exchanges (e.g., taking turns in speaking, waiting for everyone's attention). In addition, the speed and flexibility of computer-mediated communication might focus attention on the task, since the salient information conveyed will be words rather than the group or individuals with whom one is communicating. In contrast, computer-mediation might reduce communication efficiency. For example, typing and reading is more difficult than speaking and listening. Also, the lack of social feedback might decrease the efficiency of interpersonal communication. For example, not being able to murmur "hmmm" impedes one's ability to communicate comprehension of the other person's message efficiently (Kraut and Lewis, 1984).

Communication efficiency could be measured as the time required to reach a consensus, the number of task-oriented remarks as a fraction of total remarks (i.e., remarks which were related to the decision process or content), the number of decision proposals as a fraction of total remarks (i.e., the number of times group members suggested a solution to the problem), and the quality of decisions.

Communication distribution. If computer-mediated communication focuses attention on text, and if it fails to communicate differentiating social cues such as status, then communication rates should be distributed more equally. This is an especially interesting hypothesis for military personnel, where status cues have a large effect on behavior.

In addition to participation patterns among team members, it will also be important to measure the distribution and quantity of information. If all members are connected to the same computer network, then individuals may receive information that they would not have received in face-to-face groups. How will the distribution of information affect the decision making process? Will staff leaders receive more or less information on the computer? Visual information is easier to turn off or miss (close eyes, turn head but cannot "close ears"); will this influence receipt of priority information?

Group Effects

Leadership. It has been argued that the role of leader in computer-mediated groups is ambiguous. Certainly, status cues are reduced, participation is more equal, and leader emergence is less likely in groups communicating via computer. Status in the military is rank, position, and, at times, task dependent. Not only is this status visible, but it is rarely ignored or circumvented. Therefore, it seems doubtful that military leaders will lose their ability to lead, regardless of the communication media. What is less apparent is how military leaders will be perceived electronically. Will the hierarchical chain of command be ignored by staff officers who feel compelled to relay information directly to the top? Will military leaders get too involved at the lower levels of decision making, micro-managing their team rather than delegating function responsibilities to others? In contrast, lower level staff officers might not send information up the hierarchy if they know that top personnel are able to keep track of their activities automatically.

Group norms. In tasks where there is a norm, computer-mediated groups may be less likely to be influenced by the norm. Normative influence can be measured in cases where norms of interaction are well established. Possibly in the formal setting of the military, where group members interact frequently, some group norms may be easily identified.

Consensus development. The process by which groups reach consensus depends on the type of task. Consensus development in non-military decision making tasks, where a high degree of uncertainty is involved, is usually achieved through a majority opinion. However, consensus development in problem solving tasks typically requires one person with the correct solution to allow the group to reach agreement. Consensus tends to take longer in computer-mediated groups, especially when tasks are judgmental. Perhaps in problem solving tasks, consensus will be reached more quickly in computer groups.

Conformity. The pressure to conform to group opinion is lower in computer-mediated groups. In military tasks where group members share common goals and experiences, conformity may be the norm rather than the exception. Furthermore, if computer-mediated groups offer more opportunities to hear minority opinions, then the risk of "groupthink" might be reduced.

Although highly-shared models of the decision task can reduce information overload, conformity to group opinion is not necessarily a desirable group effect. One way to determine a group's mental model of decision

making is through protocol analysis. Obviously, descriptions of mental models will be needed to produce computer decision aids to assist group members in reaching an effective decision outcome. If the design of an experiment is to include a decision maker's cognitive map of his or her problem space, then protocol analyses are required.

Recommended Issues for Initial Investigation

The number of issues listed in this section is sufficiently large to prohibit the design of a compact sequence of experiments to achieve practical resolutions. We, therefore recommend a smaller set to be used for definition of initial studies.

Mode of communication. Little, if any, research in the area of computer-mediated communication has been done to understand the effects of graphic communication over long distances. Since military staff tasks are so dependent on graphic displays such as maps and overlays, it seems imperative to consider the effect of graphic communication technology on group decision making. Another important mode of communication in military staff tasks is voice or audio communication. It has been argued that the military environment will always include voice communications, and that problems are solved more efficiently when there is a voice channel available (e.g., Chapanis et al., 1976). Therefore, voice communication should be investigated, along with computer-mediated and face-to-face communications.

Role of leader. Although the role of a military leader is essential to effective decision making, the literature tells us very little about what to expect from leaders communicating via electronic media. In order to carefully study the effect of leadership on computer-mediated groups, we would design a study where one member of the group is the leader, and has rank and authority over the other group members, and has the final say on all decisions. This leader would also be responsible for accomplishment of the task, quality control and conflict resolution. This leader or supervisor would be responsible for selecting a solution when the supervised participants could not reach an agreement.

Functional groupings. Since military staff tasks are divided along functional lines, we might want to look at how more than one functional group carries out their tasks and the process of consensus development. By including the role of a leader, we could also examine how leaders choose among different sets of alternative solutions. Most importantly, from a survivability standpoint, we would want to know what happens to the decision making process when an entire functional group disappears before completing their task. It is expected that computer-mediated groups will be able to recover from the loss of a functional group with less difficulty than face-to-face groups because of the storage capability of computers.

Group norms. If we assume that military staff officers conduct their work through coordination and frequent interaction with others, then it is likely that these groups have developed norms of interaction. In order to study the influence of performance norms on groups, a task where there is a normatively correct answer will permit quantitative measurement. Normative

influences may be reduced in computer-mediated groups compared to face-to-face groups; however, this should be empirically studied, especially in a military setting.

SECTION V

BIBLIOGRAPHY

Aircraft Armaments, Inc. (1963). Teleconferencing: An experimental task (Research Paper P-112). Washington, D.C.: Institute for Defense Analyses. (AD 601 929).

Altman, I. (1966). Aspects of the criterion problem in small group-research. II. The analysis of group tasks. Acta Psychologica, 25, 199-221.

Banks, J. H., Hardy, G. D., Scott, T. D., & Jennings, J. W. (1975). Elements of a battalion integrated sensor system: Operator and team effectiveness. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Ord Field Unit. (ARI Research Report 1187; AD A025 811).

Bavelas, A. (1963). Teleconferencing: Guidelines for research (Research Paper P-107). Washington, D.C.: Institute for Defense Analyses. (AD 601 925).

Bavelas, A., Belden, T. G., Glenn, E. S., Orlansky, J., Schwartz, J., & Sinaiko, H. W. (1964). Teleconferencing: Summary of a preliminary research project (IDA Study S-138). Washington, D.C.: Institute for Defense Analyses. (AD 441 977)

Bazerman, M. H. (1986). Judgment in managerial decision making. New York: John Wiley.

Bell, M. A. (1982). Phases in group problem solving. Small Group Behavior, 13, 475-495.

Bowen, D. D., & Siegel, J. P. (1973). Process and performance: A longitudinal study of the reactions of small task groups to periodic performance feedback. Human Relations, 26, 433-448.

Brehmer, B., & Allard, R. (1986). Dynamic decision making: The effects of task complexity and feedback delay. Unpublished draft research report. Uppsala, Sweden: Department of Psychology, Uppsala University.

Carnevale, P. J. E., Pruitt, D. G., & Seilheimer, S. D. (1981). Looking and competing. Accountability and visual access in integrative bargaining. Journal of Personality and Social Psychology, 40, 111-120

Chapanis, A., Ochsman, R. B., Parrish, R. N., & Weeks, G. D. (1972). Studies in interactive communication: I. The effects of four communication modes on the behavior of teams during cooperative problem solving. Human Factors, 14, 487-509.

Chapanis, A. (1976). Human Factors in teleconferencing systems, Final Report (NSF/RA-760575). Washington, DC: National Science Foundation. (PB268453).

Collins, J. J. (1977). A study of potential contributions of small group behavior research to team training technology development. Alexandria, VA: Essex Corporation.

Crowe, W., Hicklin, M., Kelly, M., Obermayer, R. W., & Satzer, W. (1981). Team training through communications control: Final Report (NAVATRAEQUIPCEN 80-C-0095-1). Thousand Oaks, CA: Vreuls Research Corp.

Crumley, L. M. (Ed.) (1985). Design of a modular laboratory for research on tactical C2. ARI Working Paper FLv FU 85-2. Alexandria, VA: ARI.

Cvetkovich, G., & Baumgardner, S. R. (1973). Attitude polarization: The relative influence of discussion group structure and reference group norms. Journal of Personality & Social Psychology, 26, 159-165.

Davis, R., & Smith, R. G. (1983). Negotiation as a metaphor for distributed problem solving. Artificial Intelligence, 20, 63-109.

Department of the Army (1984). Staff organization and operations (FM 101-5). Washington, DC: Author.

Dubrovsky, V., Siegel, J., Kiesler, S., & McGuire, T. W. (1983). Simultaneous mode versus sequential mode in real-time computer-mediated conferencing. In A. T. Pope & L. D. Haugh (Eds.), Proceedings of the Human Factors Society 27th Annual Meeting (Norfolk, VA; Oct. 10-14). Santa Monica, CA: Human Factors Society.

Dyer, J. (1984). Team research and team training: A state-of-the-art review. In F. A. Muckler (Ed.), Human Factors Review (pp. 285-323). Santa Monica, CA: The Human Factors Society.

Eaton, N. K., & Neff, J. F. (1978). The effects of t nk crew turbulence on tank gunner performance (ARI Technical Paper 350). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A061 178)

Fischhoff, B., & [illegible]nson, S. (1985). The possibility of distributed decision making. In R. Weissinger-Baylon & J. March (Eds.), Political-Military decision making. New York: Pitman.

Fleishman, E. A. (1975). Toward a taxonomy of human performance. American Psychologist, 30, 1127-1149.

Fleishman, E. A., & Quaintance, M. K. (1984). Taxonomies of human performance: The description of human tasks. San Diego, CA: Academic Press.

Forgays, D. G., & [illegible]y, B[illegible] (1957). Combat performance characteristics associated w[illegible] chan[illegible]s in the membership of medium-bomber crews (AFPTRC-TN-57-120). San Antonio, TX: Lackland AFB, Air Force Personnel and Training Research Center. (AD 14 6414).

Forsyth, D. R. (1983). An [illegible]oduction to group dynamics. Monterey, CA: Brooks/Cole.

Gersick, C. J. G. (1985). Time and transition in work teams: Towards a new model of group development. Unpublished manuscript.

Guetzkow, H., & Simon, H. A. (1955). The impact of certain communication nets upon organization and performance in task-oriented groups. Management Science, 1, 233-250.

Hackman, J.R. (1969). Toward understanding the role of tasks in behavioral research. Acta Psychologica, 31, 97-128.

Hackman, J. R., Brousseau, K. R., & Weiss, J. A. (1976). The interaction of task design and group performance strategies in determining group effectiveness. Organizational Behavior & Human Performance, 16, 350-365.

Havaron, M. D., & McGrath, J. E. (1961). The contribution of the leader to the effectiveness of small military groups. In L. Petrullo & B. M. Bass (Eds.), Leadership and interpersonal behavior (pp. 167-178). New York: Holt, Rinehart & Winston.

Hewett, T. T., O'Brien, G. E., & Hornik, J. (1974). The effects of work organization, leadership style, and member compatibility upon the productivity of small groups working on a manipulative task. Organizational Behavior & Human Performance, 11, 283-301. (AD A001 364).

Hiltz, S. R. (1982). Experiments and experiences with computerized conferencing. In R. Landau, J. Bair and J. Siegman (Eds.), Emerging office systems. Norwood, NJ: Albex, 182-204.

Hiltz, S. R., Johnson, K., & Agle, G. (1978). Replicating Bales problem solving experiments on a computerized conferencing system. Report 8. Newark, NJ: New Jersey Institute of Technology Computerized Conferencing and Communications Center.

Hiltz, S. R., & Turoff, M. (1978). The network nation: Human communication via computer. Reading, MA: Addison-Wesley.

Hiltz, S. R., Turoff, M., & Johnson, K. (1985). Mode of communication and risky shift: A controlled experiment with computerized conferencing and anonymity in a large corporation (Research Report 21). Newark, NJ: Computerized Conferencing and Communications Center, New Jersey Institute of Technology.

Hirokawa, R. Y. (1983). Group communication and problem solving effectiveness: An investigation of group phases. Human Communication Research, 9, 291-305.

Horrocks, J. E., Heermann, E., & Krug, R. #. (1961). Team training III: An approach to optimum methods and procedures (NAVTRAEQUIPCEN 198-3). Columbus, OH: Ohio State University. (AD 267 666)

Janis, I. L., & Mann, L. (1977). Decision making. New York: Free Press.

Johansen, R., Vallee, J., & Spangler, K. (1979). Electronic meetings: Technical alternatives and social choices. Reading MA: Addison-Wesley.

Johnston, W. A., & Briggs, G. E. (1968). Team performance as a function of task arrangement and work load. Journal of Applied Psychology, 52, 89-94.

Johnston, W. A., & Nawrocki, L. H. (1982). The effect of simulated team feedback on the performance of good and poor trackers (Technical Report AFOSR-66-2541). Columbus, OH: Ohio State University, Human Performance Center, (AD 644 480)

Kahneman, D., Slovic, P., & Tversky, A. (1982). Judgement under uncertainty Heuristics and biases. Cambridge: Cambridge University Press.

Kabanoff, B., & O'Brien, G. E. (1979). The effects of task type and cooperation upon group products and performance. Organizational Behavior & Human Performance, 23, 163-181.

Kerr, E. B., & Hiltz, S. R. (1982). Computer-mediated communication systems: Status and Evaluation. New York: Academic Press.

Kidd, J. S. (1961). A comparison of one-, two-, and three-man work units under various conditions of work load. Journal of Applied Psychology, 45, 195-200.

Kidd, J. S., & Hooper, J. J. (1959). Division of responsibility between two controllers and load balancing flexibility in a radar approach control team: A study in human engineering aspects of radar air control (WADC TR 58-473). Columbus, OH: Ohio State University, Laboaratory of Aviation Psychology. (AD 214 616)

Kiesler, S., Siegel, J., & McKGuire, T. W. (1984). Social psychological aspects of computer-mediated communication. American Psychologist, 39, 1123-1134.

Kiesler, S., Zubrow, D., Moses, A. M., & Geller, V. (1985). Affect in computer mediated communication: An experiment in synchronous terminal-to-terminal discussion. Human-Computer Interaction, 1, 77-104.

Kinkade, R. G., & Kidd, J. S. (1959). The effect of team size and inter-member communication on decision-making performance (WADC TR 58-474). Wright-Patterson AFB, OH: Aero Medical Laboratory. (AD 215 621)

Klaus, D. J., & Glaser, R. (1968). Increasing team proficiency through training: 8. Final Summary Report (NR 154-079). Team Training Laboratory, American Institutes for Research.

Koriat, A., Lichtenstein, S., & Fischhoff, B. (1980). Reasons for confidence. Journal of Experimental Psychology: Human Learning and Memory, 6, 107-118.

Kraut, R. E., & Lewis, S. H. (1984). Some functions of feedback in conversation. In H. Applegate & J. Sypher (Eds.), Understanding interpersonal communication: Social, cognitive, and strategic processes in children and adults. Beverley Hills, CA: Sage.

Kreuger, F., & Chapanis, A. (1980). Conferencing and teleconferencing in three communication modes as a function of the number of conferees. Ergonomics, 23 (2), 103-122.

Kurke, M. I. (1961). Operational Sequence Diagrams in system design. Human Factors, 3, 66-73.

Lanzetta, J. T., & Roby, T. B. (1956). Group performance as a function of work-distribution patterns and task load. Sociometry, 19, 95-104.

Leavitt, H. J. (1951). Some effects of certain communication patterns on group performance. Journal of Abnormal & Social Psychology, 46, 38-50.

Linstone, H. A., & Turoff, M. (Eds.) (1975). The Delphi method: Techniques and applications. Reading, MA: Addison-Wesley.

Lyman, J. (1986). Distributed problem solving with a computer intermediary resource. Los Angeles: University of California.

Martino, J. P. (1972). Technologic l forecasting for decisionmaking. New York: American Elsevier.

Matlin, M. (1983). Cognition. New York: Holt-Rinehart.

McDaniel, W. T., & Dodd, J. R. (1972). Minuteman combat crew integrity: Its effect on job satisfaction and job performance. Unpublished Master's thesis. Wright-Patterson AFB, OH: Air University. (AD 750 850)

McDermott Associates. (1982). Evaluation of teleconferencing facilities (NZERDC-P-65). Auckland, New Zealand: New Zealand Energy Research and Development Committee, University of Auckland. (DE83 901630)

Meister, D. (1976). Behavioral foundations of system development. New York: John Wiley & Sons.

Metlay, W., Liebling, D., Silverstein, N., Halaty;n, A., Zimberg, A., & Richter, E. (1985). Methodology for the assessment of the command group planning process. Hempstead, Long Is., NY: Hofstra University.

Miller, J. F., & Chapman, R. S. (1985). SALT: Systematic Analysis of Language Transcripts. Madison, WI: Language Analysis Laboaratory, University of Wisconsin.

Morgan, B. B., Glickman, A. S., Woodard, E. A., Blaiwes, A. S., & Salas, E. (1986). Measurement of team behaviors in a Navy environment (NTSC TR-86-014). Orlando, FL: Human Factors Division, Naval Training Systems Center.

Nebeker, D. M., Dockstader, S. L., & Vickers, R. R. (1975). A comparison of the effects of individual and team performance feedback upon subsequent performance (NPRDC TR k75-35). San Diego, CA: Navy Personnel Research and Development Center. (AD A010 131)

Newell, A., & Simon, H. (1972). Human problem solving. Englewood Cliffs, NJ: Prentice-Hall.

Nieva, V. F., Fleishman, E. A., & Rieck, A. (1978). Team dimensions: Their identity, their measurement, and their relationships. Washington, DC: Advanced Research Resources Organization.

Nisbett, R. E., & Ross, L. (1980). Human inference: Strategies and shortcomings of social judgment. Englewood Cliffs, NJ: Prentice-Hall.

Obermayer, R. W., Slemon, G. K., Johnston, D. L., & Hicklin, M. (1984). Team training: Knowledge-based simulation for team members (NAVTRAEQUIPCEN 82-C-0140-1). Thousand Oaks, CA: Vreuls Research Corp.

O'Brien, G. (1967). Methods of analyzing group tasks (TR No. 46). Urbana, IL: Department of Psychology, Group effectiveness Research Laboratory. (AD 647 762)

O'Brien, G. E., & Owens, A. G. (1969). Effects of organizational structure upon correlations between member abilities and group productivity (TR 75 [69-41]). Urbana, IL: Department of Psychology, Group Effectiveness Laboratory. (AD 692 407)

Ochsman, R. B., & Chapanis, A. (1974). The effects of 10 communications modes on the behavior of teams during co-operative problem-solving. International Journal of Man-Machine Studies, 6, 579-619.

Orlansky, J. (1963). Feasibility of a research and development program (Research Paper P-105). Washington, D.C.: Institute for Defense Analyses. (AD 601 923)

Price, C. (1975). Conferencing via computer: Cost effective communication for the era of force choice. In H. A. Linstone & M. Turoff (Eds.), The Delphi method: Techniques and applications (pp. 497-516). Reading, MA: Addison-Wesley.

Reaser, J. M., Stewart, S. R., & Tiede, R. V. (1982). A methodology for and identification of command and control group behaviors. McLean, VA: Science Applications, Inc.

Rice, R. E. (1984). The New Media: Communication, research and technology. Beverly Hills, CA: Sage Publications.

Rizzo, W. A. (1980). Navy team training: Some critical issues. In S. E. Golden & P. W. Thorndike (Eds.), Proceedings of the RAND team performance workshop (Working Draft 547-ONR). Santa Monica, CA: RAND Corp.

Roby, T. B., & Lanzetta, J. T. (1958). Considerations in the analysis of group tasks. Psychological Bulletin, 55, 88-101.

Schweiger, D. M., Anderson, C. R., & Locke, E. W. (1985). Complex decision making: A longitudinal study of process and performance. Organizational Behavior & Human Decision Processes, 36, 245-272.

Scott, W. R. (1981). Organizations: Rational, natural, and open systems. Englewood Cliffs, NJ: Prentice Hall.

Shiflett, S. (1979). Toward a general model of small group productivity Psychological Bulletin, 86, 67-79.

Shure, G. H., Rogers, M. S., Larsen, T. M., & Tassone, J. (1962). Group planning and task effectiveness. Sociometry, 25, 263-282.

Siegel, J., Dubrovsky, V., Kiesler, S., & McGuire, T. W. (1986). Group processes in computer-mediated communication. Organizational Behavior & Human Decision Processes, 37, 157-187.

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1977). Behavioral decision theory. Annual Review of Psychology, 28, 1-39.

Smith, D. H. (1967). A parsimonious definition of "group": Toward a conceptual clarity and scientific utility. Sociological Inquiry, 37, 141-167.

Stefik, M., Foster, G., Bobrow, D. G., Kahn, K., Lanning, S., & Suchman, L. (1987). Beyond the chalkboard: Computer support for collaboration and problem solving in meetings. Communications of the ACM, 30 (1), 32-47.

Steiner, I. D. (1966). Models for inferring relationships between group size and potential group productivity. Behavioral Science, 11, 273-283.

Steiner, I. D. (1972). Group process and productivity. New York: Academic Press.

Tapscott, D. (1982). Investigating the electronic office. Datamation, March, 130-138.

Tuckman, B. W. (1965). Development sequence in small groups. Psychological Bulletin, 63, 384-399.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. Science, 185, 1124-1131.

Tziner, A. and Eden, D. (1985). Effects of crew composition on crew performance: Does the whole equal the sum of the parts? Journal of Applied Psychology, 70 (1), 85-93.

Vallee, J., Johansen, R., Lipinski, H., & Wilson, T. (1977). Group communication through computers (Vol. 4). Menlo Park, CA: Institute for the Future.

Vallee, J., Johansen, R., Randolph, R., & Hastings, A. (1978). Group communication through computers: Vol. 4, Social, Managerial, and Economic Issues. Menlo Park, CA: Institute for the Future.

Vest, K. F., Olson, K. A., Jones, P., & Clements, F. (1984). Transfers and enhancements of the teleconferencing system and support of the special operations planning aids (DARPA Contract MDA903-84-C-0008, Technical Report CMSI/TR-85/01). Arlington, VA: Computer Systems Management, Inc. (AD A159 523)

Wagner, H., Hibbits, N., Rosenblatt, R. D., & Schulz, R. (1977). Team training and evaluation strategies: State-of-the-art (HumRRO Technical Report 77-1). Alexandria, Human Resources Research Organization.

Weatley, E. H. I. (1981). Strategies of command decision making. (AMTE-N82-22088). Middlesex, London: Admiralty Marine Technology Establishment.

Weeks, G. D., & Chapanis, A. (1976). Cooperative versus conflictive problem solving in three telecommunication modes. Perceptual & Motor Skills, 42, 879-917.

Wheaton, G. R. (1968). Development of a taxonomy of human performance: A review of classificatory systems relating to tasks and performance (AIR-726-12/68/TR-1). Washington, DC: American Institute for Research. (AD 689 411)

Williams, E. (1977). Experimental comparisons of face-to-face and computer-mediated communication: A Review. Psychological Bulletin, 84, 963-976.

Wohl, J. G. (1981). Force management decision requirements for Air Force tactical command and control. IEEE Transcripts on Systems, Man, and Cybernetics, SMC-11 (9), 618-639.

Zander, A. (1971). Motives and goals in groups. New York: Academic Press.

APPENDIX A

A COMPARISON OF COMPUTER-MEDIATED AND FACE-TO-FACE RESEARCH

A comparison of task, group structure, and variables in computer mediated (CM)and Face-to-Face (FTF) decision making. "Ref" is the source of the information. See the abbreviated reference list at the end of this Appendix. Full references are in the Bibliography.

Table A-1

A Comparison of Selected Research

			Variables	
Ref	Task	Group Structure	Independent	Dependent
1	Directing fire fighting units to fires.	1 subject	*information feedback delay *task complexity	*Success-fires put out *Resource allocation
2	*Geographic orientation *Equipment assembly	*2 subj teams	*communication mode -communication rich -voice -handwriting -typewriting	*time *various behaviors *various linguistic measures
3	Variables listed here are summarized from those pages & are not broken down into independent & dependent variables. *task factors -cooperative vs competitive -manual vs mental -simple vs complex		*general factors -individual vs group -group size -group composition -group organization/ division of effort -procedural flexibility -communication mode/pattern -feedback *performance factors -task outcome, success, etc. -decision shift (risky shift) -perceived performance -group processes/ strategy	

Table A-1 (Continued)

A Comparison of Selected Research

Ref	Task	Group Structure	Variables: Independent	Variables: Dependent
			*social factors -motivation -individual personalities -group cohesiveness -patterns of interaction -group & indiv. abilities	
4	None. Overview of research designs. See article for more variables.	*n/a	*information detail, organization, etc. *FTF, CM (& others) *info presentation *group structure	*parameters of selected info *time *alternative solutions *errors
5	Group discussion of questionnaire.	*3 subj teams	*structure based on preexperiment attitudes	*attitude shift
6	*Career choice (choice dilemma)	*5 subj groups	*communication mode -simultaneous -sequential *problem	*time *choice shift *participation -amount -equality *No. of task related remarks *verbal measures
7	Choice dilemma: weight cost/benefit of a business opportunity	*5 midlevel mgrs/group *peers (no leader)	*communication mode -FTF -CM with names -CM with aliases	*group behavior (had to agree on level of risk to take) *amount/pattern of participation *subjective satisfaction
8	Solving an urban traffic planning problem	*4 subjects	*none	*solution success & processes

Table A-1 (Continued)

A Comparison of Selected Research

Ref	Task	Group Structure	Variables: Independent	Variables: Dependent
9	None. Review of research methods.	*group	*mode (see above)	*decision time *dec. quality *consensus *satisfaction
10	Study of affective experiences during CM discussions.	*2 subjects	*FTF vs CM *high/low anxiety	*physiological arousal *subjective affect *expressive behavior (i.e., message content)
11	Tactical battle-field simulation	*3 subjects -1 task per subject	*communication method: -broadcast -selective -preset rules for communication	*time to dec. *msg content
12	Computer assisted war game	*unknown	*unknown	*Many. See article.
13	Reach a consensus on a choice dilemma problem	*3 subject groups	*FTF vs CM (CM involved names OR aliases)	*communication efficiency -time -No. of remarks -proposals/ No. of remarks *social equalization *uninhibited communication *choice shift

Table A-1 (Continued)

A Comparison of Selected Research

Ref	Task	Group Structure	Variables: Independent	Variables: Dependent
14	*class scheduling *geographic orientation *issue ranking *budget negotiation	*2 subj teams	*comm channels: -audio only -audio & visual -teletypewriter -FTF *method -cooperative -conflicting	*time to solve *behavior *transcription *message length *rate (words per minute)

1. Brehmer, B., & Allard, R. (1986).
2. Chapanis, A., Ochsman, R. B., Parrish, R. N., & Weeks, G. D. (1972).
3. Collins, J. J. (1977).
4. Crumley, L. M. (Ed.). (1985).
5. Cvetkovich, G., & Baumgardner, S. R. (1973).
6. Dubrovsky, V., Siegel, J., Kiesler, S., & McGuire, T. W. (1983).
7. Hiltz, S. R., Turoff, M., & Johnson, K. (1985).
8. Hirokawa, R. Y. (1983).
9. Kerr, E. B., & Hiltz, S. R. (1982).
10. Kiesler, S., Zubrow, D., Moses, A. M., & Geller, V. (1985).
11. Lyman, J. (1986).
12. Reaser, J. M., Stewart, S., & Tiede, R. V. (1982).
13. Siegel, J., Dubrovsky, V., Kiesler, S., & McGuire, T. W. (1986).
14. Weeks, G. D., & Chapanis, A. (1976).

APPENDIX B

ADDITIONAL LISTING OF RESEARCH FACTORS

Table B-1 contains the factors taken from small group research that are relevant to military distributed command and control (C2) decision making teams. Brief descriptions and research conclusions are given in Table 4 for some of the factors. Unfortunately, many of the factors in Table B-1 covary and are, or have the potential to be, confounded. Some of these are: divisible tasks and distributed groups, divisible and collaborative tasks, and computer communication quality and communication structure.

Table B-1

Small Group Research Factors Relevant to Distributed C2

A. Task Parameters
   1. Coherence
      a. Divisible - separable subtasks
      b. Unitary - no subtasks
   2. Level of performance
      a. Maximal - high quantity of output
      b. Optimal - high quality output
      c. Correct - task has a correct solution
   3. Method
      a. Additive - sum of individual efforts
      b. Compensatory - average consensus
      c. Disjunctive - specific answer from a set of alternatives
         (1) conflictive
      d. Conjunctive - members work together > large amount of member participation
         (1) collaborative - individual subtasks
         (2) cooperative - common subtasks
      e. Discretionary - methods & individual contributions can vary
   4. Type
      a. Problem solving
      b. Choice dilemma
      c. Discussion
      d. Game
   5. Non-task factors
      a. Interference - interruptions with non-task related work
      b. Time stress - task must be completed within a set time limit
      c. Information organization - information for solving a problem is available when it is needed > increased efficiency
   6. Ability demands of the task
      a. Logical reasoning - inductive & deductive
      b. Mathematical reasoning
      c. Memory
      d. Spatial
      e. Time sharing - doing two tasks simultaneously
      f. Verbal ability - includes speaking, reading, & writing

Table B-1 (Continued)

Small Group Research Factors Relevant to Distributed C2

B. Group Size
   1. Dyad > Delicate balance of power or power goes to one member
   2. Triad > Easier conflict resolution than dyad because of odd number of members
   3. Increase in group size (other factors constant) > decreased time for communication by any one member, increased reliance on the leader, decreased influence of the leader, fewer members communicating, decreased desire to communicate, changes in the distribution of communication (i.e., who's talking), tendency to address remarks to subgroups rather than the group as a whole, decreased rate of interaction among members

C. Group Structure
   1. Intermember relations
      a. Rules for interaction & task - A goal & method for achieving it are well specified > increased performance
      b. No rules > increased reliance on other group members
      c. Workload distributed equally
      d. Unevenly distributed workload
   2. Roles
      a. Members are peers
      b. One member is the leader
         (1) active - leader resolves conflicts
         (2) passive - leader is neutral

D. Communication Parameters
   1. Communication network (L = Leader, S = Subordinate)
      a. Direct Dyad: S1 --- S2
      b. Asymmetric triad: S1 --- S2 --- L
      c. Symmetric triad: S1 --- L --- S2
      d. Complete triad: S1 --- L --- S2

   2. Communication structure
      a. Face-to-face (FTF) - Centralized decision making > outperform decentralized groups on simple tasks, usually more efficient than CM/A groups, wordier communication than CM/A or voice only communication.
      b. Distributed with Computer (DC) - Decentralized decision making using computers for communication > independence, autonomy, outperformance of centralized groups on complex tasks, little role differentiation (members are peers), increased opinion differences relative to FTF, short & uninhibited communication, larger risk taking by members relative to FTF, increased tendency to share information.
         (1) quality of computer communication
            (a) immediate response - similar to INSYNC
            (b) delayed response - similar to electronic mail
            (c) interaction options - available input devices, graphics capabilities, etc.

Table B-1 (Continued)

Small Group Research Factors Relevant to Distributed C2

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3. Communication content
   a. Information/data saturation - overloaded channels > decreased efficiency
   b. Task related - Communication restricted to task information > increased performance
   c. Unrestricted content - Communication contains task and non-task information > decreased performance

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Note. The right arrow, >, should be read as "leads to."